Built Environment – Healthy Communities, Healthy Homes, Healthy People

Final Report

July 15-16, 2002

Research Triangle Park, North Carolina

Edited by

Shobha Srinivasan, Liam O'Fallon, and Allen Dearry

NIEHS

Acknowledgements

We, at the National Institute of Environmental Health Sciences, would like to acknowledge the generous support from the National Institutes of Health's Office of Rare Diseases and Office of Behavioral and Social Science Research. Their contributions were vital to the positive outcomes of this conference.

Table of Contents

Executive Summary

Shobha Srinivasan, Liam O'Fallon, and Allen Dearry,
National Institute of Environmental Health Sciences

Introduction

The built environment— human-modified places such as homes, schools, workplaces, parks, industrial areas, farms, roads and highways—is our most important habitat, since 80% of North Americans live in towns and cities and spend 90% of their time indoors (Hancock, 2002). To date, much of the discussion on the built environment has focused on the challenges of providing adequate transportation (roads, highways, infrastructure, public transportation), on issues relating to urban sprawl, air pollution due to increased traffic, the unavailability of sidewalks and the lack of a natural environment. New evidence however increasingly recognizes that even the places where we live and work clearly affect our health (Wilson, Seal, McManigal, Lovins, Cureton, Browning, 1998); yet causal relationships between the built environment and specific human illnesses are often difficult to ascertain (Hodgson, 2002). Although some recent research explores the effect of improved built environments on physical activity (Handy, Boarnet, Ewing, Killingsworth, 2002), asthma (Rauh, Chew, Garfinkel, 2002), obesity (Morland, Wing, Diez Roux, Poole, 2002), cardiovascular and lung cancer mortality (Pope et al, 2002), and mental health (Halpern, 1995; Weich, Blanchard, Prince, Burton, Erens, Sproston, 2002), there remains a pressing need for more concerted research to identify mechanisms by which the built environment adversely impacts health and to develop appropriate interventions to reduce or eliminate harmful health effects. These research efforts are necessitated by the growing costs of health care associated with higher chronic disease incidence (e.g., obesity, asthma, cardiovascular disease, cancer). Etiology of all these diseases complex diseases is directly related to factors in the broad physical, chemical and social environment, including those attributable to the built environment.

Objective of the Conference

The conference, "Built Environment—Healthy Communities, Healthy Homes, Healthy People: Multilevel, Interdisciplinary Research Approaches," convened July 15-16,2002 in Research Triangle Park, North Carolina, focused on the state of the science and explored future directions in conducting research on built environment and health. The conference was cosponsored by National Institute of Environmental Health Sciences (NIEHS), Office of Rare Diseases(ORD), and the Office of Behavioral and Social Science Research (OBSSR). The objective was to delineate areas of research by which we can better understand the connection between specific illnesses and health challenges in the built environment. Speakers described current research examining connections between the built environment and human health and discussed challenges in developing sustainable communities that seek to balance social, economic, cultural, and ecological infrastructure with human health and development.

The conference was organized around three central themes relating to the built environment: Environmental Health and Sustainable Communities; Health Impacts; and Partnerships for Environmentally Healthful Communities. In addition, organizers invited two keynote speakers to provide a theoretical framework for the conference. Session presenters highlighted the state of the science and provided general recommendations for future research in this field.

The report is organized along the same lines as the conference. The report provides summaries/articles from the presenters and keynote speakers.

Definitions:
For the purpose of the conference, the following definitions of built environment and environmental health were adopted.

Built Environment:

> *The built environment is part of the overall ecosystem of our earth. It includes land-use planning and policies that impact our communities in urban, rural and suburban areas. It encompasses all buildings, spaces and products that are created, or modified, by people. It includes our homes, schools, workplaces, parks/recreation areas, business areas and roads. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains, and across the country in the form of highways*
> (Health Canada, 1997).

Environmental Health:

> *In its broadest sense, environmental health comprises those aspects of human health, disease, and injury that are determined or influenced by factors in the environment. This includes not only the study of the direct pathological effects of various chemical, physical, and biological agents, but also the effects on health of the broad physical and social environment, which includes housing, urban development, land-use and transportation, industry, and agriculture*
> (Healthy People 2010, 2000).

Session Highlights

Keynote Speakers:
Dr. Richard Jackson elucidated various health consequences of urban sprawl as well as unplanned and unmanaged developments. His article *"Creating a Healthy Environment: The Impact of the Built Environment on Public Health"* is included in this report.

Dr. Trevor Hancock discussed Sir Benjamin Ward Richardson's concept of *Hygeia* and its relevance to us in the 21st century. He then described the global impact of climate changes and their effect on human health. His article *"Healthy Communities Must Also Be Sustainable Communities"* summarizes the health benefits of sustainable development. Also included here is a summary of his presentation at the conference.

Session 1: *Environmental Health and Sustainable Communities*
The first of the three sessions focused on providing a theoretical perspective. The session stressed the importance of including environmental health in policy deliberations so as to create, in the long term, communities that are sustainable. The three presentations provided a broad based framework for the discussion on built environment and the creation of sustainable communities which incorporate improved environmental and public health. Frumkin spoke of the challenges faced in operationalizing the concept of sustainability and discussed some indicators for sustainability as developed by the Santa Monica Sustainable City Program. Rauh outlined the challenges and the health problems of deteriorated housing in low-income communities. Karolides stressed the importance of understanding human dependence on nature and the need to incorporate the natural environment into the built

environment, which has positive consequences for human health, the environment, and long-term economic benefits.

Session 2: *Health Impacts*
The second session highlighted need for concerted research to impact policy and planning for creation of communities that are environmentally healthful. Presenters addressed the impact of the built environment and urban ecosystems on air and water quality in homes, offices, and industry, the system of transportation and emissions from automobiles, etc. Discussions emphasized the importance of planning that is cognizant of environmental health in creating healthy communities, healthy homes and healthy people. Thurston described effects of power generation and motor vehicle emissions on ozone changes and of particulate matter on health. Frank explored designs of the built environment and its impact on travel, air quality, and how we spend our time. He suggested a model for developing an intervention program for improved health. Williams discussed disparities created by the built environment and showed how these inequities are actually experienced by low-income Hispanic communities in accessing clean drinking water in Tuscon, Arizona.

Session 3: *Partnerships for Environmentally Healthful Communities*
The final session focused on the creation of communities that are cognizant of the environment and the health of their citizens and promote partnerships among policy makers, governments, researchers, communities, and health specialists who have an interdisciplinary perspective. The three session presenters highlighted several programs that have developed partnerships to create sustainable communities that have a positive impact on public health. Lawrence discussed the high levels of pollution and health problems for surrounding communities due to replacement of small family owned farms by large mechanized agricultural farms. Jacobs outlined problems of high lead levels in homes and the cost of maintaining dilapidated housing and various partnerships needed to address these issues, especially for children. Horsley described the success of *Healthy Seattle's Communities Count* program and the collaborative process in developing social and health indicators based on the community's needs.

Meeting Recommendations
The one and a half day meeting generated several ideas for future research and collaborations. Some of the major recommendations include:

1. Develop effective measures and indicators for sustainable communities.

2. Conduct multidisciplinary research on the positive health impacts of sustainable and planned communities.

3. Assess the environmental health benefits of efficient or alternate energy (for transportation, agriculture, architecture, community design, etc).

4. Develop models to incorporate cost effectiveness when adopting environmentally sustainable technologies.

5. Create coordinated programs among federal and non-federal agencies that address research on the built environment.

6. Encourage interdisciplinary programs for training and research within governmental and non-governmental agencies.

7. Improve communication strategies among various partners; especially encourage community participation in research endeavors.

8. Develop multilevel techniques of measurement and longitudinal models of analysis for assessing the impact of the built environment on sustainable communities. These measures and models should account for individual, community and systemic variables including biological factors, socioeconomic factors, neighborhood and physical environment variables, etc.

9. Identify factors and variables that mediate and moderate built environment health effects.

10. Study methods and channels to translate research findings into policy and to the community-at-large that improve public health.

References

Hancock T. Indicators of environmental health in the urban setting. Can J Public Health. 2002; 93(1): 45-51.

Wilson A, Seal JL, McManigal LA, Lovins LH, Cureton M, Browning WD. Green Development: Integrating Ecology and Real Estate. John Wiley. 1998.

Hodgson M. Indoor environmental exposures and symptoms. Environmental Health Perspective. 2002; 110(4): 663-667.

Handy SL, Boarnet MG, Ewing R, Killingsworth RE. How the built environment affects physical activity: Views from urban planning. Am J Prev Med. 2002; 23: 64-73.

Rauh VA, Chew GL, Garfinkel RS. Deteriorated housing contributes to high cockroach allergen levels in inner-city households. Environmental Health Perspectives Supplements. 2002; 110(2): 323-7.

Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med. 2002; 22(1): 23-29.

Pope A, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, Thurston GD. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA. 2002; 287: 1131-41.

Halpern D. More than bricks and mortar? Mental health and the built environment. London, Taylor and Francis. 1995.

Weich S, Blanchard M, Prince M, Burton E, Erens B, Sproston K. Mental health and the built environment: Cross-sectional survey of individual and contextual risk factors for depression. Br J Psychiatry. 2002; 180: 428-433.

Health Canada. Health and environment: Partners for life. Ottawa, Health Canada. 1997.

U.S. Department of Health and Human Services. Healthy People 2010. Washington, DC, U.S. Department of Health and Human Services. 2000.

Keynote Presentations

Creating a Healthy Environment: The Impact of the Built Environment on Public Health

Richard J. Jackson,
National Center for Environmental Health
Centers for Disease Control and Prevention
and
Chris Kochtitzky,
National Center for Environmental Health
Centers for Disease Control and Prevention

Taken from the
Sprawl Watch Clearinghouse Monograph Series

Acknowledgements

Sprawl Watch Clearinghouse would like to thank Jonathan Dushoff, of Princeton University; Peter Engelke, of the City and Regional Planning Program, College of Architecture, Georgia Institute of Technology; Karen Roof, of the National Association of County and City Health Officials; Marla Hollander, of the Robert Wood Johnson Foundation; Rich Killingsworth, of the CDC's National Center for Chronic Disease Prevention and Health Promotion; Pat Meehan, of the CDC's National Center for Environmental Health; Lee Epstein, of the Chesapeake Bay Foundation; Chuck Connerly, of the Florida State University Department of Urban and Regional Planning; Bob Deyle, of the Florida State University Department of Urban and Regional Planning; Rebecca Miles, of the Florida State University Department of Urban and Regional Planning; Rich Shieber, of the CDC's National Center for Injury Prevention and Control; Bruce Stiftel, of the Florida State University Department of Urban and Regional Planning; Dorothy Sussman, of the CDC's National Center for Environmental Health; Patti Seikus, of the CDC's National Center for Environmental Health; Don Lollar, of the CDC's National Center for Birth Defects and Developmental Disabilities; Maisha Kambon, CDC's National Center for Environmental Health; Robert Weissman, of Essential Information and Betsy Garside, of the American Farmland Trust for their help in editing this report and the Educational Foundation of America whose support made this report possible.

About the Authors

Dr. Richard Joseph Jackson, MD, MPH

Dr. Richard Jackson is the Director of the National Center for Environmental Health of the Centers for Disease Control and Prevention. During his tenure at NCEH, he has worked to increase support for stronger environmental health protection efforts throughout federal agencies, to engage CDC and local and state health departments in the genetics "revolution," and to increase efforts to improve the nutritional status of people in developing countries. In addition, Dr. Jackson is collaborating with groups and individuals from many disciplines; planners, architects, engineers, academicians, and policy makers' to explore the implications of urban sprawl on the nation's environmental health.

Jackson received his baccalaureate degree from St. Peter's College in Jersey City; a Master of Medical Sciences degree from Rutgers Medical School in New Brunswick; his M.D. from the University of California, San Francisco; and his M.P.H. in epidemiology from the University of California at Berkeley.

Chris Kochtitzky, MSP

Chris Kochtitzky is the Associate Director for Policy and Planning in the Centers for Disease Control and Preventions National Center for Environmental Health, Division of Emergency and Environmental Health Services. Mr. Kochtitzky was hired as senior legislative analyst at the Centers for Disease Control and Prevention's (CDC's) National Center for Environmental Health (NCEH). NCEH is one of CDC's key centers with responsibilities involving the impact that the environment (both natural and manmade) has on human health. In his years at NCEH, Mr. Kochtitzky has also served as Acting Deputy Associate Director of the Office of Planning, Evaluation, and Legislation, which is responsible for strategic planning and policy analysis within the center.

Kochtitzky received a BA in political science in 1989 from Millsaps College and an MS in planning, with a concentration in environmental and natural resources planning, from Florida State University in 1992.

About Sprawl Watch Clearinghouse

The Sprawl Watch Clearinghouse mission is to make the tools, techniques, and strategies developed to manage growth, accessible to citizens, grassroots organizations, environmentalists, public officials, planners, architects, the media and business leaders. At the Clearinghouse we identify, collect, compile, and disseminate information on the best land use practices, for those listed above.

Sprawl Watch Clearinghouse is a nonprofit organization based in Washington, DC
Allison Smiley, Executive Director

This report and many other sources of information on sprawl and smart growth are available on the World Wide Web at **www.sprawlwatch.org**

Preface

Here at the start of the 21st century our understanding of which factors promote health and which damage health has grown considerably. The diseases of the 21st century will be "chronic" diseases, those that steal vitality and productivity, and consume time and money. These diseases-heart disease, diabetes, obesity, asthma, and depression- are diseases that can be moderated by how we design and build our human environment. It is now accepted that, in addition to direct hazards from infectious diseases and environmental toxins, human behaviors play a critical role in determining human health. As we begin to include consideration of these factors into our health-related decision-making, we must additionally guard against using too narrow a definition of the environment. Every person has a stake in environmental public health, and as environments deteriorate, so does the physical and mental health of the people who live in them. There is a connection, for example, between the fact that the urban sprawl we live with daily makes no room for sidewalks or bike paths and the fact that we are an overweight, heart disease-ridden society.

Obesity can increase the risk of (adult-onset) type 2 diabetes by as much as 34 fold, and diabetes is a major risk factor for amputations, blindness, kidney failure, and heart disease. The most effective weight loss strategies are those that include an increase in overall physical activity. In a recent type 2 diabetes trial, weight loss and physical activity were more effective in controlling the disease than medication. In addition, for treatment of relatively mild cases of anxiety and depression, physical activity is as effective as the most commonly prescribed medications. It is dishonest to tell our citizens to walk, jog, or bicycle when there is no safe or welcoming place to pursue these "life-saving" activities.

Respiratory disease, especially asthma, is increasing yearly in the U.S. population. Bad air makes lung diseases, especially asthma, worse. The more hours in automobiles, driving over impervious highways that generate massive tree-removal, clearly degrade air quality. When the Atlanta Olympic Games in 1996 brought about a reduction in auto use by 22.5%, asthma admissions to ERs and hospitals also decreased by 41.6%. Less driving, better public transport, well designed landscape and residential density will improve air quality more than will additional roadways.

In order to address these critical health problems we must seize opportunities to form coalitions between doctors, nurses, and public health professionals and others such as architects, builders, planners and transportation officials, so that we are all "at the table" when environmental decisions are made. Such decisions include whether to install sidewalks in the next subdivision. It means thinking about what constitutes safe and affordable housing, safe neighborhoods, providing green space for people to enjoy where they live and work, and rethinking how we travel from one place to another.

Land-use decisions are just as much public health decisions as are decisions about food preparation. What, for example, are the implications for children with asthma of building yet another expressway? We must also question whether a fatality involving a pedestrian isn't actually the result of poor urban planning, thoughtless land use, or inferior urban design rather than "simply" a motor vehicle crash. We must be alert to the health benefits, including less stress, lower blood pressure, and overall improved physical and mental health, that can result when people live and work in accessible, safe, well-designed, thoughtful structures and landscapes. We must measure the impact of environmental decisions on real people, and we must begin, in earnest, to frame those decisions in light of the well being of children, not only in this country but across the globe.

Richard J. Jackson, MD, MPH
Director, CDC's National Center for Environmental Health

Introduction

When people consider factors adversely affecting their health, they generally focus on influences, such as poor diet or the need for more exercise. Rarely do they consider less traditional factors, such as housing characteristics, land-use patterns, transportation choices, or architectural or urban-design decisions, as potential health hazards. However, when these factors are ignored or poorly executed, the ecosystems in our communities collapse, people suffer the consequences. We have always known that a 2-hour commute to work each day on America's freeways is not a pleasant experience; it is also becoming clear that it is an unhealthy experience. We see evidence every day that Americans exercise less often and suffer higher levels of stress than they did in the past. Yet we often fail to make the connection between these all-too-common facets of everyday life and how unhealthy we are. As America increasingly becomes a nation that permits and even encourages thoughtless development and unmanaged growth, the impact of these factors grows clearer, and we ignore them at our peril.

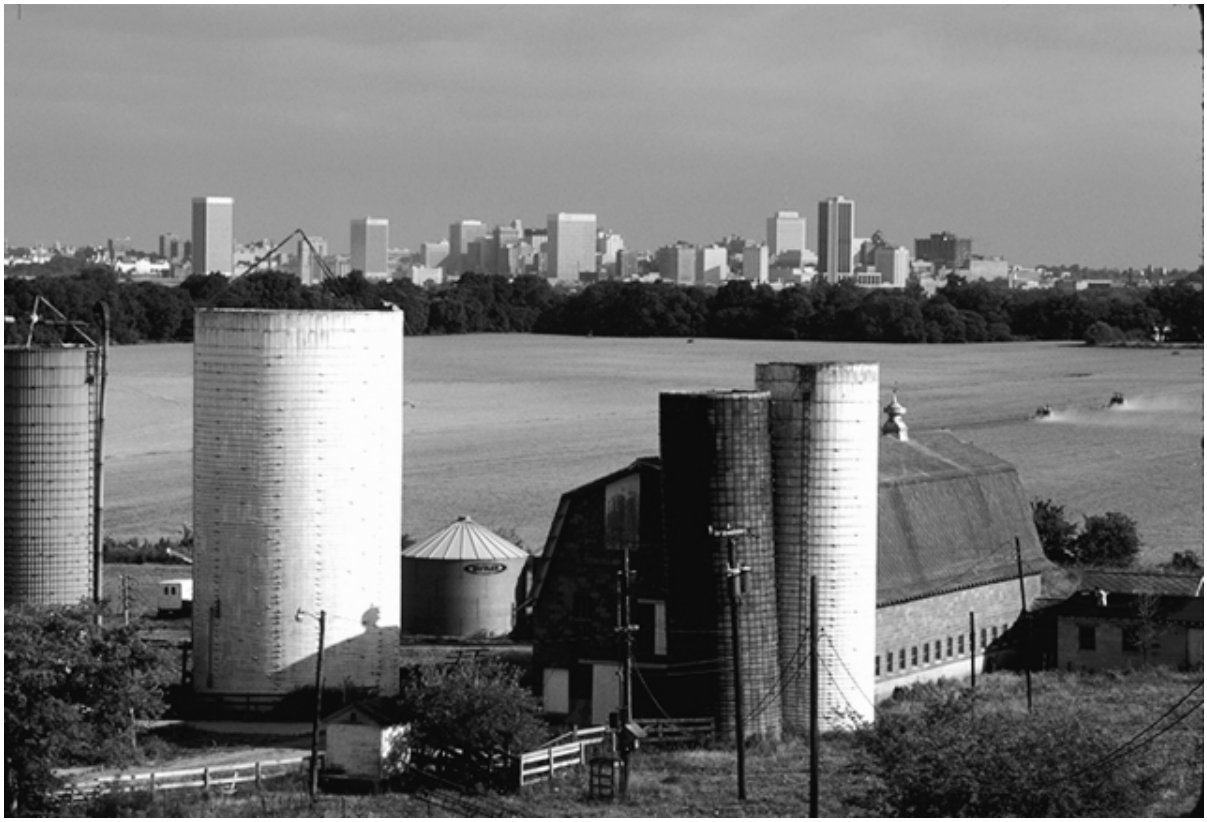


Photo: USDA

Land-use planning and zoning have their roots in a desire to protect the public's health. As far back as 1926, the U.S. Supreme Court, in *Village of Euclid vs. Ambler Realty Co.*, cited public health protection as one of the basic responsibilities of local governments, thus giving them a legal mandate to restrict or control land-use decisions in a community.[2] In this monograph, we address some of these land-use decisions, discuss how they affect our health, and offer some suggestions on how public health professionals can collaborate with their colleagues in land-use planning and urban design to help ensure the health and quality of life of the people in their communities.

In recent years, public health organizations have emphasized that public health agencies and programs must not only control disease, but also work to prevent it. The World Health Organization (WHO) has defined health as "a state of complete physical, mental, and social well-being, not just the absence of disease or infirmity."[3] The National Academy of Science's Institute of Medicine has asserted that the public health system should "fulfill society's interest in assuring conditions in which people can be healthy."[4] Environmental public health initiatives have historically been among the most effective approaches for assuring healthy living conditions. In 1854, Dr. John Snow was credited with taking bold action when he suspected that contaminated water from a public pump on Broad Street was causing a deadly cholera outbreak in London. As a result of this discovery and Dr. Snow's actions to remove the handle on the pump, the cholera outbreak ended. Much of the improvement in disease death rates in the last century can be attributed to basic environmental public health actions such as Dr. Snow's that resulted in improved sanitation, cleaner air and water, injury prevention, and protection of citizens from dangers posed by industrial pollution in their communities.

We believe that applying public health criteria to land-use and urban design decisions could substantially improve the health and quality of life of the American people. Therefore, in this monograph, we focus mainly on the following:

- The relation of land-use decisions to air quality and respiratory health;
- The built environment (including all man-made physical components of human settlements such as buildings, streets, open spaces, and infrastructure) in terms of whether it promotes or discourages physical activity;
- The impact of urban design on the number of pedestrian injuries and deaths, particularly among children;
- The choices communities make about the built environment that improve mobility and the quality of life for their elderly and disabled residents; and
- The ways that various land-use decisions affect community water quality, sanitation, and the incidence of disease outbreaks.

A brief summary of other health impacts of urban sprawl is also included, with a final section that describes some steps that both the planning community and the public health community can take to ensure that public health concerns figure prominently in decisions made about the built environment.

Land-use and Its Effects on Air Quality and Respiratory Health

Sprawl — uncontrolled, poorly planned, low-density, and single-use community growth — depends on individual motor vehicles to flourish. As people move farther and farther from cities, they inevitably will travel longer distances to work, shop, and play. From 1960 through 1990, the percentage of workers with jobs outside their counties of residence increased by 200 percent, while the proportion of workers commuting within their counties of residence declined.[5] This trend contributed to an increase in the number of vehicle miles traveled in passenger cars — an increase of more than 250 percent (915 billion miles) from 1960 through 1997.[6] This dependence on the automobile has only accelerated in recent years. For instance, according to the Sierra Club, the average American driver spends 443 hours each year behind the wheel — the equivalent of 55 nine-hour days or 11 work weeks.[7] Residents of cities that have grown more over the last decade have also experienced a greater increase in the average time spent traveling in a car than residents of cities where growth has remained stable. From 1992 through 1996, the increase in the number of annual person-hours of delay spent in an automobile in Los Angeles was 9 percent; in Atlanta 44 percent; in Orlando 62 percent; and in Kansas City 81 percent.[8]

This increase in driving time results in an increase in air pollution and in the incidence of respiratory diseases. Despite tremendous progress in reducing U.S. air pollution since the passage of the Clean Air Act almost 30 years ago, cars and trucks are still a major source of pollution, because even though individual cars pollute less, the number of cars and trucks and the number of miles people drive increases.[9] According to a recent report completed by the Congressional Research Service, in 1997, on-road vehicles accounted for about 58 percent of carbon monoxide (CO) emissions in the United States, nearly 30 percent of nitrogen oxides (NO_x), roughly 27 percent of volatile organic compounds (VOCs), and about 9 percent of particulate matter (PM). NO_x and VOCs contribute to ground-level ozone pollution, which is known as smog.[10, 11]

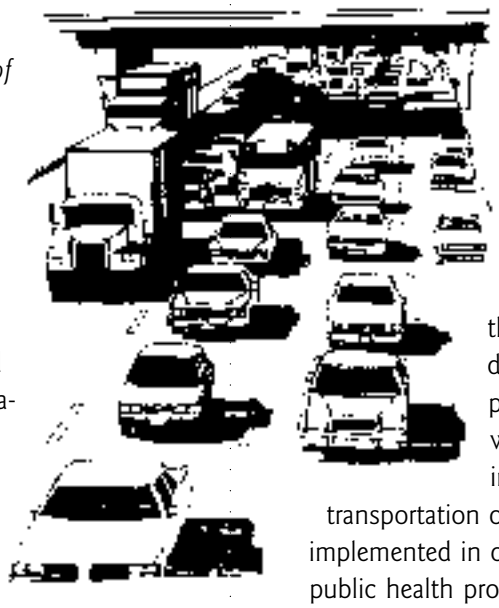
Research presented on the impact of automobiles and the transportation sector on human health at the Third Ministerial Conference on Environment and Health held in London in 1999 indicated the following:

- Motor vehicle traffic is the main source of ground-level urban concentrations of air pollutants with recognized hazardous properties. In Northern Europe, this traffic contributes practically all CO, 75 percent of NO_x, and about 40 percent of the particulate matter (PM10) concentrations.
- Approximately 36,000 to 129,000 adult deaths a year can be attributed to long-term exposure to air pollution generated by traffic in European cities.[12]

Also presented at the conference were results from a recent study of the health effects of air pollutants from traffic in Austria, France and Switzerland and their related costs. This study, using comparable methods, found that air pollution caused 6 percent of total mortality in the three countries, more than 40,000 deaths per year. About half of all mortality caused by air pollution was attributed to motorized traffic. This corresponds to about twice the number of deaths due to traffic accidents in these countries. When researchers analyzed the data from the study they found that automobile-related pollution was responsible for more deaths than traffic accidents. The economic burden of the health impact of automobile pollution was estimated at more than EUR 27 billion (approximately $23.8 billion in U.S. dollars).[12]

Data from studies conducted in the United States strongly suggest significant links between

air pollution and negative health outcomes such as asthma. The President's Task Force on Environmental Health Risks and Safety Risks to Children reports that:
"Many common air pollutants, such as ozone, sulfur dioxide, and particulate matter are respiratory irritants and can exacerbate asthma. Air pollution may also act synergistically with other environmental factors to worsen asthma. For example, some evidence suggests that exposure to ozone can enhance a person's responsiveness to other inhaled allergens. Whether long term exposure to these pollutants can actually contribute to the development of asthma is not yet known."[13]



For instance, in the summer of 1997, smog pollution was responsible for more than 6 million asthma attacks, 159,000 visits to emergency rooms for treatment of asthma attacks, and 53,000 asthma-related hospitalizations.[14] Results of a study conducted by the Centers for Disease Control and Prevention (CDC) during the 1996 Olympic Games in Atlanta, at which time vehicular traffic was kept at artificially low levels by city authorities, showed that the peak daily ozone concentrations decreased 27.9 percent and peak weekday morning traffic counts dropped 22.5 percent; at the same time the number of asthma emergency medical events dropped by 41.6 percent. Non-asthma medical events did not drop during the same time period.[15] Results that support the Atlanta findings were found in a 1999 study of adverse health effects associated with ozone in the eastern United States. This study, conducted by ABT Associates, found that during a single ozone season, asthma attacks that were directly attributed to excessive ozone pollution numbered approximately 86,000 in Baltimore, 27,000 in Richmond, and 130,000 in Washington, D.C.[16]

Children with asthma are believed to be particularly sensitive to air pollution.[13] As many as 25 percent of children in America live in areas that regularly exceed the U.S. Environmental Protection Agency's (EPA) limits for ozone, more than 25 percent of which comes from auto emissions.[13] Asthma rates among children in the United States more than doubled from 1980 through 1995, from 2.3 million[17] to 5.5 million.[18] Reducing children's exposure to environmental pollutants such as ozone will reduce the frequency and severity of their asthma attacks, will reduce their dependence on medication for asthma management, and will improve their overall lung function.[13] The significant contribution of automobile use to the overall air pollution problem seems clear. As the American population drives longer distances, these problems will most likely only worsen. Therefore, it seems imperative that new transportation options be developed and implemented in order to help alleviate the public health problems related to worsening air quality in the United States.

The Built Environment and Physical Activity

People who participate in regular physical activity reap substantial health benefits. According to the Surgeon General the most significant are as follows:

- Lower mortality rates for both older and younger adults. Even moderate increases in activity are helpful;
- Lower risk for heart disease and stroke;
- Prevention or delay of the onset of high blood pressure and actual lowering of blood pressure among people with hypertension;
- Decreased risk for colon cancer;
- Lowered risk for noninsulin-dependent diabetes;
- Weight loss and redistribution of body fat; increase in muscle mass;
- Relief of the symptoms of depression and anxiety and improvement of mood; and
- Apparent improvement in health-related quality of life by enhancing psychological well-being and by improving physical functioning among people with poor health.[19]

The built environment presents both opportunities for and barriers to participation in physical activity, thereby influencing whether or not we exercise. According to a recent survey about research studies,[20] one of the more important determinants of physical activity is a person's immediate environment (one's neighborhood). One study examined environmental variables, such as the presence or absence of sidewalks, heavy traffic, hills, street lights, unattended dogs, enjoyable scenery, frequent observations of others exercising, and high levels of crime. Positive environmental determinants of physical activity included enjoyable scenery (presence associated with more activity), whereas the greatest perceived barrier was the lack of a safe place to exercise.[20] Research by CDC and others [21, 22] has also indicated that two of the main reasons given as reasons for not exercising are lack of structures or facilities (such as sidewalks

and parks) and fears about safety. Overall, CDC reports that higher levels of perceived neighborhood safety are associated with higher levels of physical activity, with the differences being greatest among racial or ethnic minorities and people older than 65 years of age.[21] Thus, people are more likely to use parks, paths, and bikeways when they are easy to get to and are safe and well maintained.

Conversely, people tend to get less exercise as outlying suburbs are further developed and the distances between malls, schools, and places of employment and residence increases. Many theories have attempted to explain the radical changes in the health status of American society, but one of the strongest theories is the significant decline in activity levels among Americans today compared with levels from 50 or 100 years ago.[23] According to the U.S. Surgeon General's *Report on Physical Activity in America*,[19] changes in our lifestyles and communities have played the greatest role in the decline of activity levels among Americans. Millions of Americans drive to and from work and use a car to run almost every errand. In 1977, children aged 5 to 15 years walked or biked for 15.8 percent of all their trips; by 1995, children made only 9.9 percent of their trips by foot or bicycle — a 37 percent decline.[24] Results of a study in South Carolina showed that students are four times more likely to walk to schools built before 1983 than to those built

more recently.[25] This would seem to point to some basic change in the "walkability" of newer schools, possibly because these schools aren't as geographically close to the students they serve or because the school's property and its environs were designed to meet the needs of automobiles rather than the needs of pedestrians and bicyclists.

In addition, many different types of urban design encourage sedentary living habits. For example, parking lots are built as close as possible to final destinations in order to increase convenience and safety for motorists. While older cities and towns were planned and built based on the practical idea that stores and services should be within walking distance of residences, the design of most new residential areas reflects the supposition that people will drive to most destinations. Work, home, school, and shopping are often separated by distances that not only discourage walking but may even necessitate the use of a car in order to reach any destination safely.

Sedentary living habits also contribute to poor health outcomes because they are a significant factor in the incidence of overweight and obesity. From 1976 through 1994, the prevalence of U.S. adults who were overweight or obese rose from 47 percent to 56 percent, and by 1999 had risen to 61 percent.[26] More disturbing, however, was the fact that the prevalence of overweight children and adolescents almost doubled during this same period.[27] Some researchers have estimated that as many as 300,000 premature chronic disease deaths each year are due to obesity.[28]

Figures 1-3 show the alarming increase in obesity prevalence among adults in the United States during a single decade.

Major health care costs are also associated with the lack of physical activity and concomitant rises in obesity rates. In 1995, the direct health care costs of obesity were estimated at $70 billion.[29] Adding to that figure the estimated direct health care costs of physical inactivity ($37 billion),[29] we can conservatively attribute an overall health care burden of more than $100 billion to obesity and low levels of physical activity in the United States each year.

Figure 1

Figure 2

Figure 3

Urban Design and Pedestrian and Bicyclist Safety

Another important issue is the impact of urban design on a number of injuries involving pedestrians and bicyclists. According to a recent report by the Surface Transportation Policy Project, in 1997 and 1998, 13 percent of all traffic fatalities — 10,696 people — were pedestrians. Approximately 1,500 of these victims were children, while 22 percent were older than 65 years of age, even though only 13 percent of the population is elderly [30]. Although Americans make fewer than 6 percent of their trips on foot, 13 percent of all traffic fatalities occur among pedestrians; of the pedestrian deaths for which information is recorded, almost 60 percent occurred in places where no crosswalk was available.[30] The report concluded that the most dangerous metropolitan areas for walkers were newer, sprawling, southern and western communities where transportation systems are more focused on the automobile at the expense of other transportation options.

A study conducted in New Zealand asserted that there are several potentially modifiable environmental risk factors for injury to child pedestrians. Particularly strong associations were found between the risk for pedestrian injuries and high traffic volume. The risk for injury to children living in neighborhoods with the highest traffic volumes was 13 times that of children living in the least-busy areas. Restricting curb parking at specific crossing points may be an effective approach to reducing children's injuries in this arena.[31]

Several regulatory and design strategies can be applied to make communities safer for both child and adult pedestrians and bicyclists. These strategies include (1) setting and enforcing lower speed limits in residential areas; (2) protecting pedestrians in crosswalks by using traffic signals; (3) instituting and enforcing "traffic-calming" measures, such as traffic circles or speed bumps; (4) providing sidewalks and pedestrian walkways; (5) providing crossing guards and bike paths in areas where most pedestrians are children, (e.g., near schools, parks, and playgrounds) and (6) providing overpasses, underpasses or tunnels for pedestrians and bicyclists to bypass particularly dangerous roads and intersections. Inherent in each strategy is a refocusing of design goals toward pedestrians and, to a degree, away from motorists.

Photo: Hugh Morris

Environmental Barriers for the Elderly and People with a Disability

Free and easy movement through public areas in the communities where we live is something most people take for granted and, if asked, would probably claim as a right. However, people with disabilities often find that they cannot move easily from place to place and that they have trouble gaining access to medical and other basic health care and social services. People with disabilities are even more vulnerable to "environmental barriers" than children or the elderly. Environmental barriers are defined as the "physical attributes of buildings, facilities, and communities which by their presence, absence, or design present unsafe conditions and/or deter access and free mobility for the physically handicapped."[32] These attributes can include the absence of ramps for wheelchairs, lack of depressed curbs (periodic breaks in curbs that act as ramps), narrow doorways that cannot accommodate various assistive devices (such as wheelchairs, motorized scooters, walkers, etc.), and lack access to mass transit routes or other public services.

Often, something as simple as the lack of a sidewalk or curb cut keeps people with disabilities from getting any physical activity at all. A study in Houston, Texas, for example, found that three out of five disabled and elderly people do not have sidewalks between their residences and the nearest bus stop.[33] An even greater percentage of these households lack depressed curbs in their neighborhoods (71 percent) and bus shelters by the nearest bus stops (76 percent). Although close to 50 percent of the elderly and disabled live within two blocks of a bus stop, the lack of sidewalks, curb cuts, and bus shelters actually makes use of the transportation system by these people impossible. Fewer than 10 percent of the disabled and elderly use public transportation in Houston. In addition, fear of crime prevents close to two-thirds of the elderly and disabled from walking to the bus stop at night.[33]

For elderly citizens and people with disabilities, these issues are not simply about convenience or even quality of life; rather, they are critical health issues. Without access in the community, these groups cannot adequately participate in physical activity, establish a community of support, or get to or use health care facilities.

Thus, lack of physical access in a community becomes a factor leading to illness and even death.[33] Efforts to address these barriers through "universal design" have begun to show significant success. The concept of universal design maintains that — *"...all products, environments and communications should be designed to consider the needs of the widest possible array of users. Universal design is a way of thinking about design that is based on the following premises: varying ability is not a special condition of the few but a common characteristic of being human, and we change physically and intellectually throughout our life. Usability and aesthetics are mutually compatible.*[34]

As land-use and urban-design decisions are made, planners, architects, and engineers must keep in mind the needs of all community members. It is easy to see that if citizens in an urban setting such as Houston have encountered environmental barriers to mobility and accessibility, people living in suburban or rural settings may face even greater challenges. Residents of the urban areas of most major cities in the United States such as Houston have access to some type of mass transit and can also find residential housing that permits some amount of pedestrian access to needed shopping and service facilities. In suburban parts of these cities and certainly in more rural areas of the country, mass transit is nonexistent, and distances to commercial facilities make pedestrian access impossible. Such circumstances can therefore make life very difficult for anyone who cannot drive or does not have easy access to an automobile, with the pronounced hardships experienced by the elderly and disabled.

The Impact of Uncontrolled Growth on Water Quality

Uncontrolled growth and the loss of greenspace that often accompanies it can drastically affect both surface and groundwater quality. Between 1970 and 1990, central Puget Sound experienced a 38 percent increase in population, while the amount of land developed in that same period rose by 87 percent. This large-scale alteration of the natural landscape had profound effects on water resources and quality. Under natural conditions, rainfall is either intercepted by vegetation or percolates slowly through the soil to receiving waters. In urbanized areas, rainfall that once filtered slowly downhill becomes surface runoff. It flows across compacted earth and impervious man-made surfaces (e.g., asphalt, concrete, rooftops often covered with oil and other pollutants) and is channeled into storm drains. This disruption of the natural hydrologic cycle causes stormwater runoff to reach streams and rivers more quickly than these water bodies can absorb it and also before it has had an adequate chance for filtration of pollutants through the ground (the flush of auto contaminants from malls and other large parking areas that runs into surface water bodies during the initial period of a heavy rainfall contributes significantly to the non-point source loading of pollutants entering streams).[35] Undisturbed forested lands generally have the highest capacity to absorb water and subsequently the lowest rates of stormwater runoff. In contrast, impervious surfaces have the highest runoff rates. The volume of stormwater that washes off one-acre parking lots is about 16 times greater than that of a comparable size meadow.[36]

According to research published in 2001 by Johns Hopkins University, more than 50 percent of waterborne disease outbreaks between 1948 and 1994 were preceded by extreme rainfall events. Outbreaks due to surface water contamination were most strongly and most immediately related, while outbreaks due to groundwater contamination were most often delayed by a month or two. These findings can, in some part, be attributed to the increase in impervious surfaces in areas of population concentration, thereby rendering the land incapable of absorbing and filtering the amount of water that falls during these extreme weather events.[37]

An additional threat to water quality posed by sprawling uncontrolled growth is the overuse of septic systems in low-density suburban and rural residential development that results in groundwater contamination. For instance, according to the 1990 United States Census, approximately 26 percent of Florida's population was served by onsite sewage treatment and disposal systems (OSTDS). More than 1.8 million systems were estimated to be in use statewide. Since 1990, approximately 40,000 new systems have been installed each year. By comparison, in 1998, the Department of Health only issued 3,651 OSTDS abandonment permits where establishments were being connected to a central sewer system. It is estimated that OSTDS discharge 450 million gallons per day of partially treated, nondisinfected wastewater.[38]

Photo: USDA

Other Potential Health Effects of Land-use Decisions

Land-use decisions and the built environment affect the way humans act and interact, with myriad impacts on public health. Sprawl and overdevelopment is closely correlated with a range of harmful public impacts:

- In a study of conflict and violence in and around public housing in Chicago, researchers found that the residents of buildings with surrounding greenspace had a stronger sense of community, had better relationships with their neighbors, and reported using less violent ways of dealing with domestic conflicts, particularly with their partners.[39]
- Urban heat islands increase the demand for cooling energy, increase the health risks associated with heat-related illnesses and deaths, and accelerate the formation of smog. Heat islands are created when natural vegetation is replaced by heat-absorbing surfaces such as building roofs and walls, parking lots, and streets. This phenomenon can raise air temperature in a city by between 2-8°F.[40, 41]
- Sprawl increases the risk of flooding. Development pressures lead to the destruction of wetlands, which are natural flood-absorbing sponges. In the last 8 years, floods in the United States killed more than 850 people and caused at least $89 billion in property damage. Much of this flooding occurred in places where weak zoning laws allowed developers to drain wetlands and build on floodplains.[42]
- Residential development next to farmland can pose unique health and quality-of-life concerns as well. In this "zone of conflict," which might extend one-third of a mile from residential development, the spillover effects of agriculture, such as excess noise, blowing dust, and pesticide overspray potentially can have negative health effects on the occupants of the residential development.[43]
- As sprawl-type development pulls people and resources away from central cities, those left behind can experience many negative consequences. School districts pressed to save money are often enticed by donations of unknowingly contaminated property or seek out the cheapest land they can find. Some of these properties, called "brownfields," are touted as the answer to all of the problems facing financially strapped school districts. Brownfields, defined by EPA as abandoned, idled, or underused industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination,[44] can, in some instances, be the only type of property a school district feels it can afford. The land is cheap, and in some cases EPA may enter into agreements with prospective purchasers of property, providing a covenant not to sue for existing contamination.[45] Some groups feel that the supposed community benefit of cleaning up and reusing an abandoned site is outweighed by the risks posed if, when these sites are redeveloped, they are only cleaned up to standards set for commercial or industrial property, rather than residential property standards which are more stringent.[46]

Washington Post

School Case Study

Marion, OH
Military Dump

River Valley High School and Middle School stand on the former site of the US Army's Marion Engineering Depot, part of which served as a dumping ground in the 1950s. In 1990, community members formed a group in response to alarming rates of leukemia and rare cancers among former students. Their efforts led to an investigation that revealed widespread campus contamination. Today, no one may exit back doors of the middle school or access several playing fields. Recently a bond issue passed to fund a new school, but students remain on the contaminated site until completion.[46]

Planners, Architects, Engineers, and Public Health Professionals Can Make a Difference

The challenge facing those with responsibility for assuring the health and quality of life of Americans is clear. We must integrate our concepts of "public health issues" with "urban planning issues." Urban planners, engineers, and architects must begin to see that they have a critical role in public health. Similarly, public health professionals need to appreciate that the built environment influences public health as much as vaccines or water quality.

In a recently published list of the 10 most important public health challenges for the new century, CDC Director Jeffrey Koplan, MD, included at least four that are significantly linked to some of the land-use and urban design issues. They are: (1) integrating physical activity into our daily lives; (2) cleaning up and protecting the environment; (3) recog-nizing the contributions of mental health to overall health and well-being; and (4) reducing the toll of violence in society.[28]

Specific actions from the public health sector to address these issues might include the following:

- Supporting research to determine the impact that changes in the built environment can have on public health, such as the addition of greenspace, sidewalks, and bike paths, and the reduction in impervious surfaces. Just as traffic studies are completed to ensure that road capacity can support new growth, so too should the public health community conduct research to determine the air quality impacts that increasing numbers of automobiles in use in a community have on its air quality. Just as engineers use data that have been collected over time in other places to determine the diameter of sewer pipe needed to serve a section of a

community, so too should public health officials use data on pedestrian injury patterns to create new urban design techniques.

- Participating in local planning processes, such as comprehensive planning meetings, zoning hearings, and urban planning workshops known as charrettes (intense, community-based, local planning and problem-solving workshops where local leaders and decision-makers develop consensus vision of the desired future of their community). Just as the developers, the neighbors, the school board, and the planners have their say in land-use decisions, so too should physicians and public health officials have the opportunity to provide input. It is their role to ask the questions such as "Why aren't there any sidewalks in a new subdivision?" or "What is the air quality impact that is expected from a widening of the local highway?" and to press for evidence to substantiate any claims upon which any new growth and development are based.
- Working with planners and other land-use professionals to provide them with the strong public health arguments they need to support "smart-growth" designs and initiatives.

The public health and medical community must play an active role in the land-use and development decisions made in their community. It is their role to make policy makers and planners aware of the health impacts of the decisions they make. It is also critical that when they find that no data or analyses exist to answer the questions that they raise, they push researchers and policy makers to collect the information they need and conduct the research to ensure that all of the impacts of various land-use decisions are known before irrevocable actions are taken.

Just as there is an expanded role for health care workers and public health professionals in making land-use planning decisions, so too is there an expanded role for urban designers and planners to begin to view themselves as a previously untapped force for public health. It is time for the planning community to remember its roots in public health protection — to remember that in the beginning many, if not most, land-use decisions were made to separate people from land-uses and industrial processes that posed a threat to their health or safety.

To reclaim their role as public health protectors, the planners and urban designers might take the following actions:

- Balancing the potential public health consequences of their choices with other considerations. "Smart growth" doesn't mean "no growth," but it does mean planned, controlled growth. The health impacts of land-use decisions need to receive at least as much consideration in development decision-making processes as economic impacts.
- Designing communities around people rather than around automobiles. Reviving the concept that the end result of urban design should be improved quality-of-life and that where people live as it relates to where they work, shop or go to school can have a dramatic impact on their health and quality of life.
- Changing existing zoning codes to encourage multiuse land-development patterns that make it possible to work, shop, and go to school within walking distance of people's homes. The influence of last century's community designers on our communities and on the behavior choices that we make everyday was seriously underestimated. The obesity epidemic in the United States was never imagined by those who made it difficult, if not impossible, to walk to the grocery store and to school and who also made it far easier to drive to the shopping mall or the movie theater across town then to walk to

such neighborhood establishments.

- Changing existing building codes to encourage building and site design that is accessible to people who have various degrees of mobility. It is a clear, if largely unrealized, fact that the more each member of society is able to participate and contribute, the better off society is. [Not only would those who were previously hampered by the inaccessibility feel better, but they also need less help to participate in society and be more able to contribute to their communities.] And all of this could be possible if appropriate design choices are made which, in most cases, would not cost appreciably more or negatively affect others.
- Encouraging greenspace development that promotes community, reduces violence, and improves mental health. The mental and physical health benefits of community parks and other green spaces have been demonstrated. The question that remains is whether communities want to spend money up front to create an environment that prevents violence and increases psychological well-being or whether they want to spend money after the fact to address the violence and stress which results from communities without parks and communal areas.

Public health professionals and those in architecture, urban design, and planning have much in common. The challenge now is for each profession to learn from each other how best to address the needs of the communities they serve, to determine what answers each has that the other needs, to create a common language, and to initiate the opportunities to use it.

To meet these challenges, we need a broader view of those factors influencing public health and a much better understanding of the interdisciplinary nature of the problem. We need a collaborative and concerted effort to influence both public health policy and other public policy on these issues in order for positive changes to take place that will improve the health and quality of life for all Americans.

Photo: Hugh Morris

References

1. Department of Health and Human Services (US). Healthy people 2010. Volume 1. Washington: DHHS; November 2000. p.8-3.

2. *Village of Euclid* v. *Ambler Realty Co.*, 272 U.S. 365 (1926) (USSC+).

3. World Health Organization. (No date). Definition of health [Online]. Available: http://www.who.int/aboutwho/en/definition.html [2001, August 6].

4. Institute of Medicine (US). The future of public health. Washington: National Academy of Sciences; 1988. p. 7.

5. Department of Transportation (US), Bureau of Transportation Statistics. (No date) Journey-to-work trends in the United States and its major metropolitan areas, 1960-1990. [Online]. Available: http://ntl.bts.gov/DOCS/473.html [2001, August 6].

6. Department of Transportation (US), Bureau of Transportation Statistics. (1999) The national transportation statistics report 1999. [Online]. Available: http://www.bts.gov/ntda/nts/NTS99/data/Chapter4/4-11.html [2001, August 6].

7. Pope, C. Solving sprawl. (1999) The Sierra Club rates the states [Online]. Available: http://www.sierraclub.org/sprawl/report99/index.asp [2001, August 6].

8. Texas Transportation Institute (1999). Urban roadway congestion annual report 1998. Table 1-54 [Online] Available: http://199.79.179.77/ntda/nts/NTS99/data/Chapter1/1-54.html [2001, August 6].

9. Environmental Protection Agency (US). Emission facts. Washington: U.S. EPA, Air and Radiation Office, Office of Mobile Sources; EPA420-F-99-040. [1999, November].

10. National Council for Science and the Environment. (1999) Congressional Research Service Report for Congress. Air quality and motor vehicles: An analysis of current and proposed emission standards [Online]. Available: http://www.cnie.org/nle/air-36.html [2001, August 6].

11. Environmental Protection Agency (US). National air quality and trends report; Washington: US EPA, Office of Air and Radiation; EPA 454/R-98-016 [1997, December]

12. World Health Organization, European Region. (1999) Third ministerial conference on environment and health, London [Online]. Available: http://www.who.dk/london99/transporte.htm [2001; August 6].

13. The President's Task Force on Environmental Health Risks and Safety Risks to Children. Asthma and the environment: A strategy to protect children (2000) [Online]. Available: http://www.epa.gov/children/whatwe/fin.pdf [2001, August 6].

14. Clean Air Network and U.S. Public Interest Research Group Education Fund. (2000) Danger in the air: Smog days in 1999 [Online]. http://www.pirg.org/reports/enviro/smog/index.html [2001, August 6].

15. Friedman, MS, et al. Impact of changes in transportation and commuting behaviors during the 1996 summer Olympic games in Atlanta on air quality and childhood asthma. JAMA 2001;285:897-905.

16. ABT Associates. Adverse health effects associated with ozone in the eastern United States. Washington: (1999).

17. Centers for Disease Control and Prevention. Surveillance for asthma–United States, 1960–1995. Mor Mortal Wkly Rep CDC Surveill Summ 1998;47(No.SS-1):1-28.

18. Massey JT, Moore TF, Parsons VL, Tadros W. Design and estimation for the National Health Interview Survey, 1985-1994. Hyattsville: Department of Health and Human Services (US), National Center for Health Statistics; 1989. (PHS)89-1384. (Vital and health statistics; series 2; no. 110).

19. Department of Health and Human Services (US). Physical activity and health: A report of the surgeon general. Washington: (1996).

20. King AC, et al. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women; Health Psych 2000;19(4):354-64.

21. Centers for Disease Control and Prevention. Neighborhood safety and the prevalence of physical inactivity –selected states, 1996. Mor Mortal Wkly Rep 1999:48(7):143-6.

22. Pate RR, et al. Physical Activity and Public Health: A Recommendation From the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273(5):402-7.

23. Nestle M, Jacobson MF. Halting the obesity epidemic: A public health policy approach. Public Health Rep 2000;115(1):12-24.

24. Corless J, Ohland G. Caught in the crosswalk: Pedestrian safety in California [Online]. Available: http://www.transact.org/ca/caught99/caught.htm [2001, August 6].

25. Kouri C. Wait for the bus [Online]. Available: http://www.scccl.org/nletter/2000summer/schools.htm [2001, August 6].

26. Centers for Disease Control and Prevention.) (No date). Prevalence of overweight and obesity among adults: United States, 1999 [Online]. Available: http://www.cdc.gov/nchs/products/pubs/pubd/hestats/obese/obse99.htm [2001, August 6].

27. Centers for Disease Control and Prevention. (No date). Prevalence of overweight among children and adolescents: United States, 1999 [Online]. Available: http://www.cdc.gov/nchs/products/pubs/pubd/hestats/overwght99.htm [2001, August 6].

28. Koplan JP, Fleming, DW. Current and future public health challenges. JAMA 2000;284(13):1697.

29. Colditz, GA. Economic costs of obesity and inactivity. Med Sci Sports Exerc 1999; S664-5.

30. Surface Transportation Policy Project (2000). Mean streets 2000: A transportation and quality of life campaign report [Online]. Available: [2001, August 6].

31. Roberts I, et al. Effect of environmental factors on risk of injury of child pedestrians by motor vehicles: A case-control study. BMJ 1995;310(6972):91-4.

32. Crum S, Foote KE (1996). Environmental and architectural barriers: How accessible is the urban environment? (1996) [Online]. Available: http://www.colorado.edu/geography/gcraft/warmup/barriers/barriers.html [2001, August 6].

33. Gilderbloom JI, Markham JP. Housing quality among the elderly: A decade of changes. Int J Aging Hum Dev1998; 46(1). Also available at http://www.louisville.edu/org/sun/housing/cd_v2/Bookarticles/Ch1.htm [2001, August 6].

34. Adaptive Environments Center. Adaptive Environments & Universal Design (No date) [Online]. Available: http://www.adaptenv.org/universal/default.asp [2001, August 6].

35. State of Pennsylvania, 21st Century Environment Commission (No date). Redefining progress: recommendations from the 21st century environment commission to Governor Tom Ridge [Online]. Available: http://www.21stcentury.state.pa.us/2001/redefining_progress.htm [2001, August 6].

36. 1000 Friends of Washington. Sprawl (No date) [Online]. Available: http://www.1000friends.org/sprawl.htm [2001, August 6].

37. Curriero FC, Patz JA, Rose JB, Lele S. The association between extreme precipitation and waterborne disease outbreaks in the United States. Am J Public Health 2001;91(8):1194-9.

38. Florida Department of Health. Departments of Community Affairs and Department of Environmental Protection. (1999) Onsite sewage treatment and disposal in Florida: Draft background paper for the Governor's study of onsite sewage treatment and disposal systems [Online]. Available: [2001, August 6].

39. Sullivan WC, Kuo FE. Do trees strengthen urban communities, reduce domestic violence? In U.S. Department of Agriculture, Forest Service, Southern Region. Forestry Report RB-FR 56, January 1996 [Online]. Available: http://www.urbanforestrysouth.org/pubs/Tech_bulletin/tb4.htm [2001 August 6].

40 Gorsevski V, Taha H., Quattrochi D, Luvall J (No date) Air pollution prevention through urban heat island mitigation: An update on the urban heat island pilot project [Online]. Available: http://www.ghcc.msfc.nasa.gov/uhipp/epa_doc.pdf [2001, August 6].

41. Blum LN, et al. Heat-related illness during extreme weather emergencies. JAMA 1998;279(19).1514.

42. The Sierra Club (No date). Sprawl fact sheet [Online]. Available: http://www.sierraclub.org/sprawl/factsheet.asp [2001, August 6].

43. American Farmland Trust (No date). Alternatives for future urban growth in California's Central Valley: The bottom line for agriculture and taxpayers [Online]. Available: http://www.farmlandinfo.org/fic/ft/cv/cv-intro.html [2001, August 6].

44. USEPA Office of Solid Waste and Emergency Response Glossary of Terms. [Online] Available: http://www.epa.gov/swerosps/bf/glossary.htm#brow [1997, September 30].

45. United States Environmental Protection Agency, Office Solid Waste and Emergency Response. Brownfields Economic Redevelopment Initiative Quick Reference Fact Sheet. EPA 500-F-00-241 [Online] Available: http://www.epa.gov/swerosps/bf/html-doc/econinit.htm [2000, October].

46. Child Proofing Our Communities: Poisoned School Campaign. Poisoned schools: invisible threats, visible actions (2001) [Online]. [2001, August 6].

Hygeia 21, or, Healthy Buildings in Healthy Communities in Healthy Ecosystems: Sustaining People and the Planet

Trevor Hancock,
Board of the Canadian Association of Physicians for the Environment

In 1875, Sir Benjamin Ward Richardson presented his vision of Hygeia, a comprehensive and detailed description of a city of health. Richardson envisaged a city of 100,000 people at a density of five houses per acre, with no buildings rising above 60 ft. Railways would run beneath the major highways and there would be a subway system. Side roads are lined with trees, there are parks and gardens everywhere and street drainage is via sewers. The houses are light and airy, brick built, smoke-free and have roof gardens, running hot and cold water, garbage chutes and main drains and sewers.

We are told that Richardson's vision of Hygeia was very influential both in Britain and in the USA (Cassedy , 1962) and echoes of it can be seen in Ebenezer Howard's Garden City, and in the New Urbanism of the late 20th century. It certainly was an inspiration to me when I came across his description of Hygeia in the late 1970's, at a time when I was developing the idea of a healthy city myself, in Toronto. It is a vision we need to update and incorporate into the work of public health for the 21st century.

It is worth recalling where we live and what constitutes the " natural" environment of humankind today. Globally, we are 50 percent urbanized - and 80% urbanized in North America , where we also spend at 90 percent of our time indoors; of the remaining 10 percent of time, we spend roughly half of it outdoors - and half of it in our cars! (Leech et el, 1996). Thus the built environment is far and away our most important environment . But at the same time, we are 100 percent part of the natural world, utterly dependent on it for the "free" ecosystem goods and services that nature provides (World Resources Institute, 2000). Yet our urbanized, industrialized society is contributing massively to the four key forms of global environmental change that are threatening our health : climate and atmospheric change, resource depletion, pollution and eco-toxicity , and loss of habitat and biodiversity resulting in species extinction (Davies and Hancock, 1997). Thus any modern version of Richardson's vision has to pay attention not only to how the built environment affects human health directly but, by affecting the natural environment, how it then affects human health indirectly, perhaps on the other side of the planet.

Our modern version of Hygeia needs to begin with the buildings we inhabit - our homes, schools, workplaces, hospitals, malls and arenas that are the settings in which we lead our lives. Beyond the obvious but essential need to build safe buildings, ensuring the healthfulness of these intimate environments where we spend 90% of our time means paying attention to all the factors that affect our health. Of particular concern is indoor air quality. What is the cumulative effect on children's ability to learn, or on the productivity of the workforce, of dust and mould, VOCs, inadequate ventilation, poor lighting, lack of fresh air, absence of plants, routine use of pesticides and other such factors that have been shown to affect health? What are we to make of the fact that many of our hospitals are unhealthy buildings for their patients and staff, and that they are major sources of solid waste and pollution, especially dioxins and mercury- principally through incineration of medical wastes (Health Care Without Harm, 2001). Is this compatible with a vision of a healthy hospital? And what are we to make

of the fact that many children in North America spend long periods of time for many years in diesel buses that expose them to unacceptable levels of carcinogenic diesel exhaust (Natural Resources Defense Council, 2001)

Then there is the impact of our buildings on the natural environment. The US construction industry uses 3 billion tonnes of raw materials annually, including 40 percent of raw stone, gravel, sand and steel, 75 percent of PVC, 25 percent of virgin wood and 40 percent of US energy resources (American Society of Healthcare Engineering, 2002). Indeed, energy use is key; Wackernagel and Rees (1996) estimated that over half the ecological footprint of a typical Canadian can be attributed to energy use, with half that energy use coming from housing and transportation. Walker and Rees (1997) found that over 60% of the housing-related ecological footprint is taken up by operating energy for housing and transportation and this rises to 82-90% of the total footprint when embodied energy use is included. They also showed that the energy footprint depends on what type of housing is built; when compared to a standard house, the footprint of a small-lot house is 92%, with a typical townhouse at 78%, a walk-up apartment at 64% and a high-rise apartment at 60%.

When we turn to the wider urban environment, again it is primarily the use of energy that is the issue - in this case, the energy used in moving people and goods. A recent composite night-time photo of the USA in the National Geographic (July 2001) vivdly shows the massive degree of urban sprawl that has occurred in just the past seven years, especially in the southeast. We have created an incredibly energy-wasteful urban form, and the health impacts include not only direct impacts arising from traffic accidents and air pollution, or the lack of physical activity that contributes not only to the epidemic of obesity, but to heart disease, cancer and other health problems (Jackson and Kochtitsky, 2001), but psychosocial impacts such as the stress of commuting and congestion leading to ‘road rage’, or the family and community deprivation time that result from long commutes. And from a global perspective, we need to be clear what the impact of the North American - and especially the U.S. - urban way of life is on the health of the rest of the world . What does it mean in terms of the potential health effects of global warming (Intergovernmental Panel on Climate Change, 2001), for example, when the U.S. - with 5 percent of the world’s population - consumes 43% of the world’s gasoline (Sheehan, 2001).

The health impacts of the energy system - from exploration through extraction and transportation to processing and distribution and ultimately to use and disposal of residues - is massive (Romm and Ervin, 1996??). It includes occupational fatalities, injuries and disease from coal mining, oil-drilling, building power plants and distribution systems; community health impacts from motor vehicle accidents, psychosocial stress and regional air pollution; and environmental health impacts from pollution, climate change and other ecosystem damage associated with energy use, including the health impacts of storms, floods and changing insect vector distribution associated with global warming.

Yet we have never done a full health impact assessment of energy use, or looked seriously at alternative, more health-enhancing energy policies. Were we to do so, I suspect the answer might help to shock us out of our excessive consumption of energy and other resources. We would, I hope, come to see that investing in healthy homes, schools, workplaces and hospitals is worthwhile; that public transportation is a much healthier option - for both human health and environmental health; that urban sprawl must be stopped and existing urban areas intensified so we can more easily walk, bike or blade to work, school or to local amenities; that we can and must build smaller vehicles and use alternative,

clean, renewable fuels; that we can-and we must - create healthier buildings in healthier and more environmentally sustainable communities if we are to leave our descendants a healthier planet.

A 21st century version of Hygeia is possible - indeed, it is essential. Moreover, it is achievable with our current technology; what is lacking is the public and political will to achieve it. On its own, public health cannot achieve Hygeia, cannot make the planet healthy and livable for future generations. But public health has a long tradition of asserting its values, of proclaiming its aspirations, and of working to marshal the political and social will to improve the health of the population. The creation of healthy people in healthy communities in a healthy world is, I believe, the supreme goal for public health in the 21st century (Hancock, 2000). The public health research community can contribute to this goal by conducting the following priority research and widely disseminating the results:

- Health impact assessments (physical, mental and social) and their associated economic costs
- Unhealthy indoor environments (especially schools and workplaces, but also including hospitals and in-vehicle environments)
- Urban sprawl and associated housing and transportation patterns (urban intensification)
- Societal energy use

References

American Society of Health Care Engineering (2002) Green Health Care Construction Guidance Statement (www.ashe.org)

Cassedy, James (1962) Hygeia: A Mid-Victorian Dream of a City of Health, J. Hist. Med., 17(2), 217-228

Davies, Kate and Hancock, Trevor (1997) The Health Implications of Global Change: a Canadian Perspective (A paper for the "Rio +5" Forum prepared for Environment Canada under the auspices of The Royal Society of Canada's Canadian Global Change Program) Ottawa: The Royal Society of Canada

Hancock, Trevor (2000) Healthy People in Healthy Communities in a Healthy World: The Science, Art and Politics of Public Health in the 21st Century Regent's Lecture, School of Public Health, University of California, Berkeley CA, Sept 27th, 2001 (Unpublished manuscript)

Health Care Wthout Harm (2001) Dioxin, PVC, and Health Care Institutions (fact sheet) Health Care Without Harm: Falls Church, VA (Also available via their website at www.noharm.org)

Intergovernmental Panel on Climate Change (2001) Climate Change 2001: Synthesis Report - Summary for Policy Makers (www.ipcc.ch/pub/tar/syr)

Jackson, Richard and Kochtitsky, Chris (2001) Creating a Healthy Environment: the Impact of the Built Environment on Public Health Washington DC, Sprawl Watch Clearinghouse (www.sprawlwatch.org)

Leech, J. A. et al (1996) "Canadian human time-activity pattern survey report and population surveyed" Chronic Diseases in Canada 17: 118-123

Natural Resources Defense Council (2001) No Breathing in the Aisles: Diesel Exhaust inside School Buses Washington DC: Natural Resources Defense Council

Richardson, Sir Benjamin (1875) Hygeia: A City of Health. London: MacMillan

Romm, J. and Ervin, C. (1996) "How Energy Policies Affect Public Health" Public Health Rep 111(5): 390-9

Sheehan, Molly O'Meara (2001) City Limits: Putting the Brakes on Sprawl Washington DC: Worldwatch Institute

Wackernagel, Mathis and Rees, William E. (1996) Our Ecological Footprint : Reducing Human Impact on the Earth Gabriola Island, BC ; Philadelphia, PA : New Society Publishers

Walker, Lynn and Rees, William (1997) "Urban Density and Ecological Footprints - an analysis of Canadian Households". In Roseland, Mark (Ed) Eco-City Dimensions: Healthy Communities, Healthy Planet Gabriola Island, BC: New Society Press

World Resources Institute (2000) World Resources 2000-2001: People and ecosystems: The fraying web of life New York, Oxford: Oxford University Press

Healthy Communities Must Also Be Sustainable Communities

Trevor Hancock,
Board of the Canadian Association of Physicians for the Environment

Healthy Communities Must Also Be Sustainable Communities

Abstract

Ultimately, our health depends on the health of the built and natural ecosystems of which we are a part. We North Americans are 80% urbanised and spend almost 90% of our time indoors. At the same time, our industrial economy is changing the Earth's climate and massively affecting the web of life. A healthy community is aware of these threats to health and strives to be more environmentally sustainable. In particular, healthy and sustainable communities must reduce energy consumption, which will help reduce air pollution and avoid climate change. However, this will mean fundamentally re-designing our communities and our way of life.

(For other discussions of the links between healthy and sustainable communities see Hancock, 1996 and Hancock, 1997 a)

"Population health, viewed within an ecological and longitudinal framework and across multiple scales, can be understood as an expression of the sustained functioning of the many ecosystems and natural cycles that constitute earth's life support systems. Although, for the moment, longevity continues to increase in most countries, these health gains will dissipate if life's ecological infrastructure is not sustained."

(McMichael et al, 1996a)

Public health measures over the ages have frequently focused on environmental measures to protect and promote health. Two and a half thousand years ago, Hippocrates wrote about the importance of air, water and other environmental factors in the locating and planning of cities and housing; the Romans built aqueducts to bring fresh water to their cities, sewers to cart away the waste and drained marshes, thus reducing malaria. Our modern era of public health traces its roots to the application of these same principles in the 19th and early 20th centuries, in the face of the massive adverse health effects of urbanization and industrialization. (See Hancock, 1997 b, for a review of some of the historical roots of the Healthy Cities movement.)

Modifying the natural and built environments has remained a key strategy in the struggle to improve the health of the public. Indeed, the environmental movement has long recognized that we best understand and relate to environmental damage when it is expressed in terms of its effect on human health. However, in the mid-20th century a subtle but important shift in our perception of the environment began to manifest itself. With the growth in both scientific and popular understanding of ecology came the realization that the environment was not something "out there", something separate and apart from humans, but rather that we are but one species in the web of life, a part of the ecosystem.

Moreover, we have come to recognise - or admit - that since North Americans are 80% urbanized and since we spend almost 90% of our time indoors, the built environment is our principal environment today. The built environment is an environment built for humans, by humans. A recent report on Health and Environment by Health Canada (1997) described it thus:

> *The built environment is part of the overall ecosystem of our earth. It encompasses all of the buildings, spaces and products that are created, or at least significantly modified, by people. It includes our homes, schools and workplaces, parks, business areas and roads. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains and across the country in the form of highways.*

There are a variety of threats to health arising directly from the quality of our housing and from the design of our cities and neighbourhoods. In turn, the built environment - whether it be a house or a whole city - has an impact on the natural environment, both locally and globally, which ultimately affects human (and ecosystem) health indirectly. Locally, these threats include air, water, soil and noise pollution and degraded natural areas and habitat. Globally, the resource demands and pollution emissions of cities contribute to climate change, depletion

of both renewable and non-renewable resources, widespread contamination of even remote ecosystems such as the Arctic and impaired ecosystem health and species extinctions.

These changes in the natural environment - from local water pollution to global climate change - in turn have an indirect impact on the health of the individual. While the precise health implications of such changes may not yet be clear, they are nonetheless real (see for example McMichael, 1993). In addressing the health implications of the built environment, then, we need to understand that there are two forms of impact:

- direct health effects: the effects of the built environment on people who live within that environment. Many of these are positive (shelter from the elements, warmth, clean water supply, etc.) but many are negative (indoor air pollution, traffic, etc.);
- indirect health effects: the effects on the health of people as a result of changes in the natural environment resulting from the construction and operation of built environments, as noted above. These effects may be experienced by people who are remote from the built environment that generates the effect.

Clearly, both the quality of our housing and the wider urban environment and the need for greater ecological sustainability are significant determinants of health and deserving of priority attention. These more sophisticated ways of understanding the environment as a determinant of health can be seen, for example, in the Report on the Health of Canadians (Federal, Provincial and Territorial Advisory Committee . . . 1996) , which has identified three challenges related to the physical environment that must be met if we are to improve the health of the public:

- foster a healthy and sustainable environment for all
    - reduce pollution
    - sustain ecosystem health
    - reduce resource consumption
- ensure suitable, adequate and affordable housing
- create safe and well designed communities.

Public health in the 21st century will be characterized by an ecological approach to the environment, an approach that was first legitimized in the Ottawa Charter for Health Promotion (WHO, 1986), which lists a stable ecosystem and sustainable resources among the prerequisites for health. This ecological approach will be especially important in built environments at the local level; the settings - homes, schools, workplaces and of course communities - in which people lead their lives. Addressing the links between health, sustainability and the built environment is an issue that is central to public health - and thus of vital concern to cities and communities that wish to be healthy. The sections that follow briefly describe the unsustainable nature of our present way of life; the concept of the sustainable community; and the relationship between the built environment and health. The article concludes with a brief overview of urban energy use as one of the key issues linking sustainablility, the built environment and health and, as an example, the relationship between urban transportation and health

Our Ecological Footprint

In a world where half of humanity lives in urban environments, and where global ecosystems and natural cycles are daily affected by our urbanized and industrialized way of life, it becomes increasingly difficult to treat the natural and built environments as separate. Humanity's influence is so pervasive and so massive that we can no longer maintain the pretence that we are separate from the planet. Our urban and industrialized way of life has a massive impact on the natural environment.

This impact has been graphically described by Wackernagel and Rees (1996) as the "ecological footprint". The concept is a simple one, although complex in its implementation. An attempt is made to calculate the area of biologically productive space required per person in order to maintain them in their current lifestyle. This requires calculating such issues as how much land is required for food production, housing, transportation, consumer goods and services. Land categories that are included in the calculation include forest, pasture, arable land, sea

space, fossil energy land and built-up land. However, the largest single component of the ecological footprint is attributable to energy consumption.

In 1997, America had a footprint of 10.3 hectares per capita, compared to 7.7 hectares per capita in Canada and 5.9 hectares per capita in Sweden. However, globally there is just 1.7 hectares of biologically productive land available per person (if we leave 0.3 heactres for the rest of creation!) while we already use 2.3 hectares per person, on average, or 35% more than is available. Our "ecological footprint" on the earth has become so massive that, were everyone to achieve the American standard of living to which many aspire, using our current technologies, we would need five more planets to sustain us today! (See the "Footprint of Nations Report" at <http://www.iclei.org/iclei/ecofoot.htm>, which is the website for the Toronto-based International Council for Local Environmental Initiatives, a leading international NGO working with local governments and communities world-wide to create more sustainable communities.)

Clearly this is not sustainable even in the short term and certainly not if we continue to aim to increase our GDP and concomitant resource use at a "modest" 3.5% per annum, which results in a doubling time of some 20 years, or a 32-fold increase in one century! Reducing our ecological footprint must become a priority concern for communities and nations if we are to ensure human and ecosystem health in the future. Creating more sustainable communities thus becomes an important public health strategy.

Sustainable communities and health

> *"A sustainable community exacts less of its inhabitants in time, wealth and maintenance, and demands less of its environment in land, water, soil and fuel." (Van der Ryn and Calthorpe, 1987)*

There is no one accepted definition of a sustainable community, although there is clearly a focus on creating communities that are more environmentally sustainable and that reduce the "ecological footprint" of the community, as noted above. However, the concept of sustainable communities includes a strong social element as well, as exemplified by Marcia Nozick in her book No Place Like Home: Building Sustainable Communities (1992).

A recent Canadian definition suggests that an ecological (or sustainable) community may be defined as one which

> "does not erode the natural capital (air, water, land, renewable and non-renewable resources) of the earth, and whose structure and function result in a harmonious relationship with the local, regional and global ecosystems. . . . ecological cities are also characterized by the strength, health and vitality of their communities and economies." (CMHC, 1995)

while in a 1996 US report from the President's Council on Sustainable Development, healthy and sustainable communities were described as

> "communities where natural and historic resources are preserved, jobs are available, sprawl is contained, neighbourhoods are secure, education is life-long, transportation and health care are accessible, and all citizens have opportunities to improve the quality of their lives" (in Beatley and Manning, 1997).

Roseland (1997) locates sustainable communities within a nexus of new approaches to the design, construction and operation of communities (and more broadly, of society as a whole) that includes a number of related concepts, including healthy cities/communities. Thus the concept of a sustainable community has come to transcend its ecological and technological origins to embrace the economic, social, political and cultural means by which we can create communities that are both environmentally and socially sustainable. Clearly, a healthy community needs to be a sustainable community as well - indeed, it can hardly be considered to be healthy if it is not also working to be more sustainable.

Unfortunately however, North America has devised the most environmentally unsustainable form of urban settlement ever seen - suburban sprawl. The ecological footprint of suburban sprawl is far higher than the footprint of higher density - and often more livable - European-style urban settlements (see Wackernagel and Rees, 1996). To begin with, suburban sprawl consumes large areas of (often) high-quality agricultural land, since cities have generally grown where there is sufficient farm land around them to support the population and create a thriving agricultural economy in the first place. Thus suburban sprawl threatens the sustainability of our domestic

agricultural resource base and our ability to feed ourselves. In addition, suburban sprawl requires more hard infrastructure per capita, which consumes more resources and also costs more.

Suburban sprawl is also enormously wasteful of another vital resource, namely energy. It creates an automobile-dependent urban form which is one of the main contributory factors to both urban air pollution and global warming. In addition, widely dispersed, low density single family dwellings are very energy inefficient with respect to heating and cooling in comparison with row housing, mid-rises and other forms of clustered housing. Since urban air pollution and global warming respectively represent immediate and long-term threats to health, becoming more energy efficient is one of the most vital challenges that healthy cities and communities face.

Urban energy use and health

> *"In a sense, cities are themselves energy -using technologies, and like energy-using technologies, they can be designed for more or less efficiency."* Torrie et al (1997)

While we can point to many ways in which energy contributes to our quality of life, almost all forms of energy use have health costs associated with them. To begin with, there are occupational, environmental and community health costs arising from the extraction, processing and transportation of the fuels themselves as well as the materials used in the construction of energy systems. In addition there are health costs arising from the construction and operation of energy systems themselves - be they nuclear power plants, hydro dams or solar heaters on the roof.

The actual use of energy also has health impacts, most notably from the pollutants emitted (eg., CO_2, heavy metals, acid emissions, radio-isotopes), some of which may have long-term, even multi-generational impacts on health. Other health impacts of energy use include deaths and injuries from motor vehicle accidents, fires and explosions. Finally, there are health costs related to the disposal of wastes and the decommissioning of power plants

Among the most important health effects of energy use are the deaths and disease that result from air pollution:

> *". . . .The vast majority of the pollutants most clearly linked to increased morbidity and mortality are energy related. In 1994, energy-related emissions [in the US] - such as those from power plants, vehicles and industry - accounted for more than 90% of emissions of sulfur dioxide, carbon monoxide, nitrogen oxides and volatile organic compounds, and for most of the smallest particulates (under 2.5 microns in diameter)."* (Romm and Ervin, 1996)

Moreover, the carbon dioxide emissions that result from the combution of fossil fuels are the principal factor driving global warming, which may have very significant direct and indirect health implications in the future (McMichael et al, 1996 b)

However, while Alexandre and De Michelis (1996) point out that some three quarters of all energy consumption occurs in urban areas, this is because that is where people are and

> "not because urban communities are inherently less efficient than lower density settlement patterns. On the contrary, the higher densities and inherent efficiencies of urban form tend to make per capita energy use in cities lower than average".

Indeed, they cite a 1993 Canadian study that found energy use per capita in Toronto to be 25% less than for the general population. They argue that

> "Since energy use is most concentrated within cities, local actions to increase energy efficiency and to foster the introduction of clean alternative energy sources are critical factors both to avoid long-term risks of global climate change and to improve the quality of life at the local level".

In addition to having energy-efficient buildings, sustainable communities are energy-efficient in other respects. Important aspects of this energy-efficiency are the design of the urban form (with important implications for transportation and the "embodied energy" involved in constructing and then operating the infrastructure - principally water and sewage treatment) and the community's energy production system.

Clearly, energy use is an important and wide-ranging issue for healthy cities and communities to address. One key aspect of such energy use, with a wide range of health implications, is the energy used in transportation of people and goods.

Urban transit and health

Globally, transportation accounts for 60% of the consumption of oil products, with Canada second only to the United States in terms of per capita transportation-related energy consumption in 1994 (Torrie et al, 1997). According to the OECD, global transportation energy consumption will increase 73% between 1990 and 2030 (National Roundtable . . . 1996, Figure 1.1).

In addition to fossil fuel depletion and air pollution, transportation adversely affects the environment because of infrastructure development, which "takes up a great deal of land, and permanently changes the character of this land surface", in particular by increasing run-off and encroaching upon natural habitats. Other environmental impacts include air pollution and modification of water systems, solid waste production, noise, accidents, and partition or destruction of neighbourhoods. (Statistics Canada, 1994)

The major issue with respect to the relationship between transportation and urban development is that low density residential suburbs with separated industrial, residential and commercial sectors, combined with long commuting distances and inadequate public transportation (itself a function of low density development) means that a typical suburban dweller uses much more energy for their transportation needs than a typical downtown dweller.

For example, in a study of the Toronto region by Gilbert (1997), as we move from the core to the periphery density declines fourfold, car ownership per household goes from 50 percent to almost 100 percent and miles driven per capita more than triples. The result is a three-fold increase in estimated CO_2 emissions (and other emissions) per capita as we move from the core to the outer suburbs. The health implications are obvious.

A good public transit system, on the other hand, contributes to the overall health and wellbeing of the community and its citizens. The health benefits of a good transit system are both direct and indirect.

> Direct health benefits: In addition to lower rates of respiratory and heart disease resulting from reduced pollution noted earlier, direct health benefits include lower accident rates because transit is a safer form of travel. According to Litman (1996) public transit has 0.66 fatal accidents per billion vehicle miles, which is about 1/20th the rate for automobiles; not just fatalities, but injuries, are reduced. Another potential benefit is a more active lifestyle; people walk and bicycle more, and will have to walk - even run - to the transit stop!
>
> Indirect health benefits may include less congestion, reduced commuting time, less noise, less stress, less cost, higher incomes, less social isolation, increased access for disadvantaged groups, the conservation of energy and resources, and reduced global warming.

Conclusion

The significance of the built form for our long-term health and wellbeing should not be underestimated. By building - and continuing to build - energy-inefficient suburbs, we are effectively locking ourselves into a long-term energy consumption pattern that is neither sustainable nor healthy nor - if the true costs were to be applied - affordable. The economic costs of the health consequences of urban air pollution are very substantial today. And while the health impacts of global warming may seem to be a long way off - both chronologically and geographically - they are well within the "lifetime" of the suburbs we are building today, and the lifespan of the infants now living in those suburbs. To be healthy, communities must be more energy efficient, more sustainable and will need to focus on steadily reducing their per capita ecological footprint.

REFERENCES

Alexandre, Ariel and De Michelis, Nicola (1996) "Environment and Energy: Lessons from the North" Environ Impact Assess Rev 167: 249-257

Beatley, Timothy and Manning, Kristy (1997) The Ecology of Place Washington, DC: Island Press

CMHC (1995) The Ecological City: Canada's Overview Ottawa: CMHC

Federal, Provincial and Territorial Advisory Committee on Population Health (1996) Report on the Health of Canadians Ottawa: Health Canada

Gilbert, R. (1997) Reducing Urban Air Pollution in APEC Economies: Draft 2 Prepared for the APEC Workshop on Air Quality and Energy management, Vancouver. Toronto: Richard Gilbert, 15 Borden St, Toronto ON Canada M5S 2M8

Hancock, Trevor (1996) "Planning and creating healthy and sustainable cities: the challenge for the 21st century." In C. Price and A. Tsouros (eds.), Our Cities, Our Future: Policies and Action for Health and Sustainable Development. Copenhagen: WHO Healthy Cities Project Office.1990

Hancock, Trevor (1997 a) "Healthy, sustainable communities: concept, fledgling practice and implications for governance" In Roseland, Mark (Ed) Eco-City Dimensions: Healthy Communities, Healthy Planet Gabriola Island, BC: New Society Press

Hancock, Trevor(1997 b) "Healthy Cities and Communities: Long tradition, hopeful prospects" National Civic Review 86(1): 11 - 21

Health Canada (1997) Health and Environment: Partners for Life Ottawa: Health Canada

Litman, Todd (1996) Defining and Quantifying Public Transit Benefits Victoria: Victoria Transport Policy Institute

McMichael, A.J. (1993) Planetary Overload Cambridge: Cambridge University Press

McMichael, A.J. et al (1996 a) Sustainable Health in a Globalized World (Beijer Discussion Paper #87) Stockholm: Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences

McMichael, A. J. et al (1996 b) Climate Change and Human Health Geneva: WHO

National Roundtable on Environment and Economy (1996) Sustainable Transportation in Canada - Backgrounder Ottawa: National Roundtable on Environment and Economy

Nozick, Marcia (1992) No Place Like Home: Building Sustainable Communities Ottawa: Canadian Council for Social Development

Romm, J. and Ervin, C. (1996) "How energy policies affect public health" Public Health Rep 111(5): 390-9

Statistics Canada (1994) Human Activity and the Environment, 1994 Ottawa: Statistics Canada

Torrie, Ralph et al (1997) Urban Energy Management and the Cities of APEC - Opportunities and Challenges (Draft Background Paper for National Roundtable on Environment and Economy, Ottawa)

Van der Ryn, Sim and Calthorpe, Peter (1987) Sustainable Communities: a new design synthesis for cities, suburbs, and towns San Francisco: Sierra Club Books

Wackernagel, Mathis and Rees, William E. (1996) Our Ecological Footprint : Reducing Human Impact on the Earth Gabriola Island, BC ; Philadelphia, PA : New Society Publishers

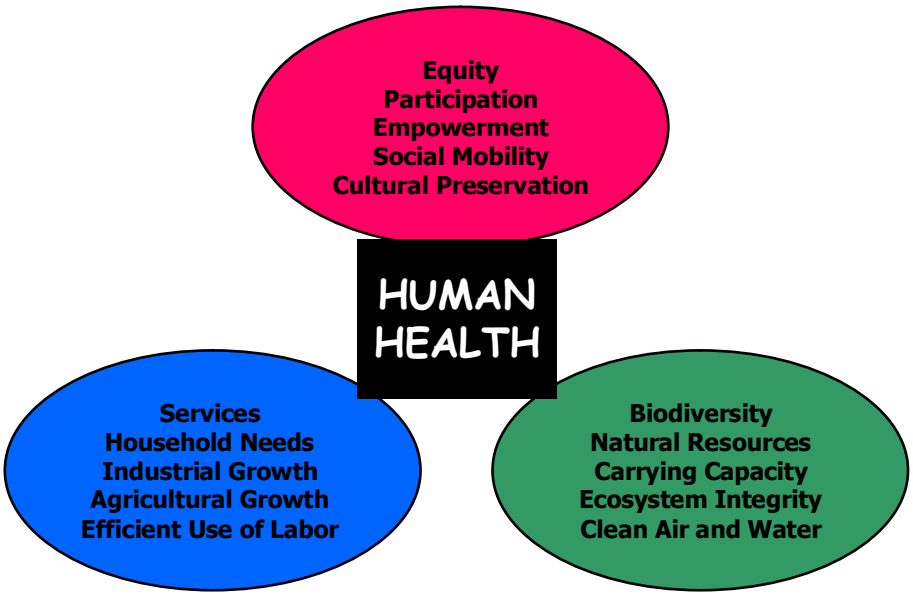
WHO (1986) The Ottawa Charter for Health Promotion Copenhagen, WHO Europe

Environmental Health and Sustainable Communities

Environmental Health and Sustainable Communities

Howard Frumkin,
Emory University

Environmental health is advanced (or undermined) on many levels, from the molecular to the household, from the community to the global. In considering the links between environmental health and the built environment, a useful framework is that of sustainability. The Brundtland Commission introduced the concept of sustainable development to a worldwide audience in its 1987 report, *Our Common Future*. That report defined sustainable development simply as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It posited a three-part structure underlying sustainable development, including social factors (pictured at the top), economic factors (pictured at the lower left), and environmental factors (pictured at the lower right). It is easy to appreciate that health sits at the intersection of these three domains.



Following this framework, sustainable communities may be defined as "…healthy communities where natural and historic resources are preserved, jobs are available, sprawl is contained, neighborhoods are secure, education is lifelong, transportation and health care are accessible, and all citizens have opportunities to improve the quality of their lives." (President's Council, 1993). This definition integrates the various aspects of sustainability that the Brundtland Commission identified, and makes it clear that the physical form of a community—the natural resource base, the land use and transportation patterns, and so on—are integrally related to human health in the community.

In 1994 the Charter of European Cities and Towns Towards Sustainability, known as the Aalborg Charter, made many of the same points:

- "We, cities & towns, understand that the idea of sustainable development helps us to base our standard of living on the carrying capacity of nature. We seek to achieve social justice, sustainable economies, and environmental sustainability. Social justice will necessarily have to be based on economic sustainability and equity, which require environmental sustainability.
- "Environmental sustainability means maintaining the natural capital. It demands from us that the rate at which we consume renewable material, water and energy resources does not exceed the rate at which the natural systems can replenish them, and that the rate at which we consume non-renewable resources does not exceed the rate at which sustainable renewable resources are replaced. Environmental sustainability also means that the rate of emitted pollutants does not exceed the capacity of the air, water, and soil to absorb and process them.
- "Furthermore, environmental sustainability entails the maintenance of biodiversity; human health; as well as air, water, and soil qualities at standards sufficient to sustain human life and well-being, as well as animal and plant life, for all time."

While the concept of sustainability is attractive, it has proven difficult to operationalize, both in research and in policy-making. What should be the environmental health research agenda that would better clarify what sustainability means for human health, and how environmental protection and human health protection can be made mutually supportive? I offer three suggestions for research topics: the natural environment as an aspect of the built environment, mental health, and indicators.

There is considerable evidence that contact with the natural environment may offer human health benefits (Frumkin, 2001). Some of this evidence is anecdotal and experiential; most of us choose to take vacations in beautiful natural places, sensing intuitively that they are restorative and even health-promoting. There is also a theoretical basis for this belief, in the concept of biophilia (Wilson, 1984). And relatively rigorous data are available. For example, post-operative patients who could view trees from their hospital windows had speedier recoveries, and less pain, than patients whose windows looked out at a brick wall (Ulrich, 1984). Similarly, prisoners whose cells provided a view of rolling countryside, with trees and greenery, had fewer sick call visits than prisoners whose could only look out at a drab prison courtyard (Moore, 1981-82). Animal contact also seems to confer health benefits; pet owners have lower blood pressure and cholesterol (Anderson et al., 1992) and enhanced survival after myocardial infarction (Firedman and Thomas, 1995) compared to non-pet owners, apparently not explained by physiological differences. Such intriguing findings demand more systematic research. Research questions include careful definition of both "nature contact," of the patients to be studied, and of the health outcomes of interest. It is important to take advantage of natural experiments, using a wide variety of epidemiologic methods. It is important for health researchers to collaborate actively with colleagues from distant disciplines such as horticulture and veterinary medicine. And it is important for disparate funding sources, ranging from the U.S. Forest Service to NIEHS, to collaborate in supporting sound research.

A second important focus of research on health, sustainability, and the build environment is mental health. This argument rests on three planks. First, mental health problems are common. Second, the built environment plays a role in mental health. Third, this link is incompletely understood.

Mental illness has a 10% point prevalence and a 25% cumulative lifetime prevalence (Surgeon General, 1999). Worldwide, it accounts for 12% of DALYs lost and 31% of YLDs; in the Americas these figures are 24% and 43% respectively (WHO, 1999). Depression is 5th leading contributor to global disease burden; this is increasing (Murray and Lopez, 1996). Five of the ten leading causes of

disability worldwide (major depression, schizophrenia, bipolar disorders, substance abuse and obsessive compulsive disorders) are mental problems (Murray and Lopez, 1996). There is evidence that the built environment plays a role in nearly all major mental health problems, including depression, anxiety, attention deficit disorder, substance abuse, and aggressive behavior. But this set of relationships is poorly understood. Aspects of the build environment that deserve research in this regard include light, noise, time spent driving, opportunities for physical activity and social interaction, and others. Since most people spend most of their time in built environments, at work, at home and in other buildings or vehicles, achieving even small increments in mental health promotion through environmental change could yield enormous benefits across society.

The third and final suggestion is methodological rather than substantive. We need to identify the best "metrics" of features of the built environment relevant to both health and sustainability. Such metrics are commonly referred to as "indicators"—quantitative measures used to measure a variety of economic, social, environmental, and political trends. Familiar examples include the Gross National Product (GNP), crime rates, the Dow Jones Industrial Average, population growth rates, and annual rainfall measurements. In the sustainability literature, there are many examples of sustainability indicators. An example, from Santa Monica (California) Sustainable City Program, is shown in the box. In general the process of developing these indicators is felt to be as important as the indicators themselves; the process is a tool for building community cohesiveness about social and environmental goals. The indicators, once developed, can be used both to perform research, and to set policy and monitor its implementation.

Sustainability Indicators, Santa Monica

- Resource conservation
  - Landfilled solid waste (tons/year)
  - Water usage (million gallons/day)
  - Energy use (milliom mBTU/year)
  - Average recycled content of city office paper purchase
- Transportation
  - Annual ridership on municipal bus line
  - Average Vehicle Ridership (AVR) of employers with >50 employees
  - % of city fleet vehicles using reduced-emission fuel
- Pollution prevention & public health protection
  - Reduction in citywide use of hazardous materials (%)
  - Underground storage tank sites needing cleanup (#)
  - Dry weather storm drain discharges to the ocean (gallons/day)
  - Citywide wastewater flow (million gallons/day)
- Community & economic development
  - Create and implement Sustainable Schools Program
  - Affordable housing units (#)
  - Public open space (acres)
  - Community gardens (#)
  - Trees in public spaces (#)
- New and revised indicators
  - Hazardous waste generated by city operations (% reduction from baseline)
  - City purchases of hazardous materials
  - Compliance with Federal UST standards for all Underground Storage Tanks (100% compliance by deadline)
  - Diversion or treatment of dry weather stormwater runoff (100% citywide compliance by deadline

Sustainability indicators should include many indicators of human health. This will help focus public attention on health implications of decisions about the built environment, emphasize the health consequences of these decisions, and ultimately facilitate the protection of health.

References

Anderson W, Reid C, Jennings G. Pet ownership and risk factors for cardiovascular disease. *Med J Australia* 1992;157:298-301.

Charter of European Cities and Towns Towards Sustainability, 1994 (available: http://www.iclei.org/europe/echarter.htm)

Friedmann E, Thomas SA. Pet ownership, social support, and one-year survival after acute myocardial infarction in the cardiac arrhythmia suppression trial (CAST). *Am J Cardiol* 1995;76:1213-17.

Frumkin H. 2001. Beyond toxicity: Human health and the natural environment. *Am J Prev Med* 20:234-40.

Moore EO. 1981-2. A prison environment's effect on health care service demands. *J Environ Systems*11:17-34.

Murray CJL, Lopez AD, eds. *The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020.* Cambridge, MA: Harvard School of Public Health on behalf of the World Health Organization and the World Bank (Global Burden of Disease and Injury Series, Vol. I), 1996.

President's Council on Sustainable Development, 1993 (available: http://clinton2.nara.gov/PCSD/Overview/index.html).

Santa Monica Sustainable City Program (available: http://www.ci.santa-monica.ca.us/environment/policy/indicators.htm)

Ulrich RS. 1984. View through a window may influence recovery from surgery. *Science* 224:420-21.

US DHHS. Mental Health: A Report of the Surgeon General. Rockville, MD: US DHHS, Substance Abuse and Mental Health Services Administration, Center for Mental Health Services, National Institutes of Health, National Institute of Mental Health, 1999.

Wilson EO. 1984. *Biophilia: The Human Bond with Other Species*. Harvard University Press, Cambridge.

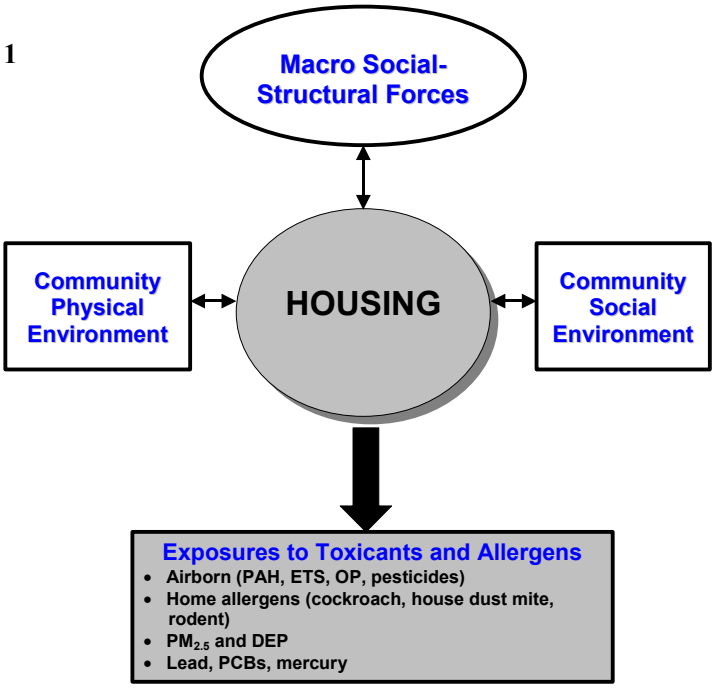
World Health Organization. *World Health Report 2001. Mental Health: New Understanding, New Hope.* Geneva: WHO, 2002.

Deteriorated Housing: A Toxic Environmental Exposure

Virginia Rauh,
Columbia University

The world we build for ourselves has profound effects on our health. In fact, the importance of adequate housing for the maintenance of health has long been a topic of scientific and public health policy discussion, but the links remain elusive. We address here three key questions:
(1) What are the important elements and purposes of housing? (2) How does housing transmit environmental influences to people, and how can we understand these relationships? That is, what is the evidence that housing parameters are associated with specific toxic exposures that increase health risks? And finally, (3) Which aspects of housing are modifiable, and can we reduce risk of environmental illness by intervening? Figure 1 depicts housing as a conduit for transmitting environmental exposures.

Figure 1



With respect to the key elements of housing, we must define and measure both the physical and social parameters. Communities are held together by physical and social infrastructures--one connected to the other such that the wider social infrastructure shapes the physical, which in turn holds the people together. The physical infrastructure consists of buildings, roads, transportation, water, sewage, air and light. Housing and quality of the overall residential setting is one of the most important components of the built environment, because of the multiple functions it serves. Housing-related conditions with important health impact can arise at multiple levels of influence (Table 1), and these influences can occur through the effects of specific exposures associated with each type of condition, at each level of influence. As shown in Table 2, there are both physical and social ways in which housing can erode health at multiple levels, and we must find ways to reliably measure these pathways and their effects.

A critical point is that we are not necessarily talking about extreme conditions, but rather the chronic stresses of overcrowding, inadequate garbage removal, location near busy transportation routes, poor ventilation, etc.—conditions that are part of the everyday lives of the residents of many urban communities.

Housing can promote health by providing warmth, light, proper disposal of waste, protection from pests, etc.; housing can erode health by forcing people to live together in crowded, unsanitary conditions. It is important to understand that the quality of housing (and its potential impact on health) is partly determined by public policy. In New York City, for example, inadequate city code enforcement and repair of city properties have led to the systematic deterioration of the housing stock and, consequently, of entire neighborhoods. These are the processes that permit or lead to environmental pollution.

Table 1-- HOUSING PARAMETERS

Social-Structural Level:
Historical Context
Urban Renewal Efforts
Relocation Policies

Neighborhood Level:
Housing Values
Housing Costs (as % of average income)
Housing Type (%): subsidized, public, private
Housing Form (%): cluster, high-rise, brownstone
Residential Stability
Vacancy Rate
Age of Dwellings
Utility Cutoffs
Homelessness Rate
Housing Code Violations
Building Permits
Tax Delinquencies

Individual Level:
Physical Condition of Housing Unit
Moves/Evictions/Length of Residence
Rent to Income Ratio
Adequacy of Utilities (heating, plumbing, cooking, lighting)

Table 2

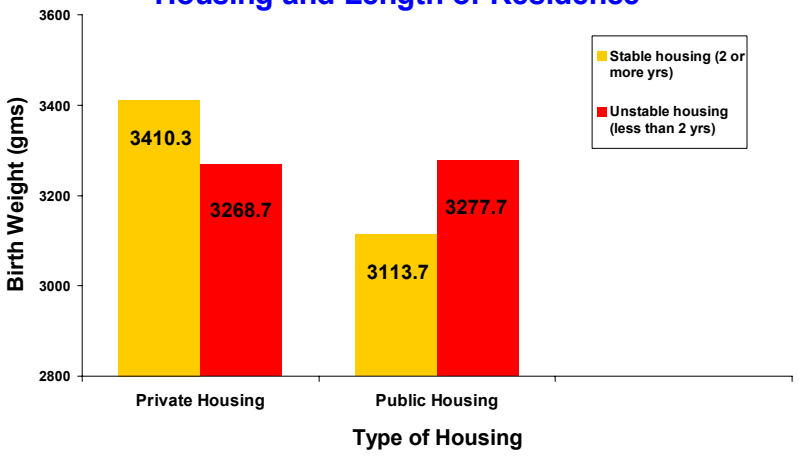
ENVIRONMENTAL HEALTH FACTORS AT DIFFERENT LEVELS OF ANALYSIS

HOUSING PARAMETERS	ENVIRONMENTAL HEALTH FACTORS	
	Physical/Material	Social
Historical Context Urban Renewal Efforts Relocation Policies	Environmental Justice Issues State/Local Environmental Regulations Zoning Codes	Social Justice Issues Political Equality Human Rights
Housing Values Housing Costs as % of income Housing Type (Public, Private, Subsidized) Housing Form (cluster, highrise, etc.) Residential Stability Vacancy Rate Age of Dwellings Utility Cutoffs Homelessness Rate Housing Code Violations New Building Permits Tax Delinquencies	Outdoor Air Quality (PAH, DEP, PM) Traffic Patterns Location of Bus Depots and Waste Transfer Stations Toxic Emissions from Businesses Neighborhood Trash Removal Coal-burning Furnaces in Schools Lead Level (Soil, Built Environment) Safety of Neighborhood Playgrounds Clean-up Efforts Pest Control (Community-wide) High Quality Food Sources	Social Cohesion Community Organizations Residential Stability Safety/Violent Crime Racial Segregation Social Capital Human Capital Crowding Information Channels Community Health Status Indicators Employment Rate Public Transportation
Physical Condition of Housing Unit (roof, leaks, holes) Moves/Evictions/Length of Residence Rent to Income Ratio Adequacy of Utilities	Indoor Air Quality (NO_2, PAH, $PM_{2.5}$) Air Exchange Home Allergens (cockroach, dust mite, rodent) Endotoxins Lead, Mercury Environmental Tobacco Smoke Use of Pesticides	Family Relationships Sense of Permanence Self-esteem Physical/ Psychological Well-being Adequate Diet Job Satisfaction

Predictably, low-income neighborhoods carry the lion's share of substandard housing, imposing additional material and social burdens on those who are least able to manage them. Against this backdrop, however, careful inspection of low-income urban neighborhoods reveals tremendous variability in quality of life and health status indicators. Poor families are a heterogeneous group, as measured by variations in social and material living conditions, physical toxicants/irritants, and child health outcomes. Material hardships have been shown to vary within income strata, and may contribute to variability in health outcomes along physical as well as social pathways (Mayer and Jencks, 1988).

The social infrastructure holds people together, comprising a society's culture, rules, values, and goals. When people disturb the physical system, the social system will also be disturbed and must reorganize itself (Wallace et al., 1996). This is true for small disturbances (one house burns) and large disturbances (a whole community gets wiped away by a flood). The likelihood that a community can re-establish itself diminishes with the magnitude of physical disruption. The history of urban renewal efforts in this country reflects, for the most part, a failure to take the social consequences of these processes into consideration, with the result that whole communities have suffered displacement, fragmentation, loss of social cohesion, and illness (e.g., Sampson et al., 1997; Fullilove, 1996). One of the consequences of urban renewal efforts is the concentration of the most disadvantaged segments of the urban black population in a few residential areas, as opposed to dispersal, and this has resulted in a kind of hypersegregation of both social and physical phenomena. Inter-neighborhood variations in housing costs and crowding are among the clearest legacies of segregation in many urban areas, and have been associated with rates of low birth weight in the city of Chicago (Roberts, 1997). An illustration from a study of social determinants of low birth weight in New York City (Shiono et al., 1997) showed that, at comparable levels of poverty, children born to women living in public housing were more likely to be LBW, and this risk increased with length of time the mother resided in public housing (Figure 2).

Figure 2--Mean Birth Weight by Type of Housing and Length of Residence



Shiono, Rauh et al., 1997, AJPH, 87(5):787-793.

Housing instability has also been identified as one of the most important predictors of 'community ill health' (as measured by community social disorganization and crime), even more important than standard sociological variables such as poverty and racial composition. Residential mobility constitutes a barrier to the development of informal local friendship networks, kinship bonds, and local organizational ties. Residential mobility may be measured at a number of levels: (1) the number of times a child has moved or the length of time in present dwelling (an individual-level variable); (2) the percentage of residents in the community who

have lived in their present dwelling for a specified period of time (a group-level derived variable); (3) patterns of in-out migration (a group-level integral variable). Residential instability may be both directly and indirectly associated with specific adverse health outcomes.

An example of how residential instability erodes community health concerns the high crime rate in many urban minority communities. Urban African Americans live in ecologically very different areas than whites; namely, areas characterized by a concentration of low-income housing projects with elevated levels of social dislocations or extreme housing instability. Rates of violent offenses are strongly influenced by variations in family structure (independent of income, region, size, density, age and racial composition)—specifically, family disruption, in both African American and white neighborhoods. The high rates of crime in African American neighborhoods derive in large part from the concentration in public housing of high levels of family disruption (Sampson et al., 1997). This suggests that residential/housing effects may be in part mediated by individual-level family functioning, so that it is important to identify risk factors and paths of influence at multiple levels.

As noted in Table 2, we can identify specific physical and chemical toxicants that may be associated with housing conditions at both the individual and the community levels. One example is the distribution of indoor allergens thought to be a factor in the origin and exacerbation of childhood asthma (Platts-Mills, 1994; Sporik et al., 1990; Gelber et al., 1993; Rosenstreich et al., 1997). Allergic sensitization to cockroaches has been related to the level of bedroom allergen exposure in children, with higher exposures among African American (Sarpong et al., 1996) and other low-income urban populations (Pollart et al., 1989). There is some evidence that the distribution of cockroach allergens is influenced by characteristics of the built environment, such as building design and management (Jones, 1998), type of foundation,and type of dwelling (apartments versus houses) (Chew et al., 1999). Goldstein and colleagues reported extremely high levels of airborne cockroach allergen in Harlem apartments, with 85% of the homes of inner-city asthmatic children having detectable cockroach allergen levels (Goldstein et al., 1987). Although several studies have investigated associations between type of housing and cockroach allergen levels, none have used a measure of housing deterioration.

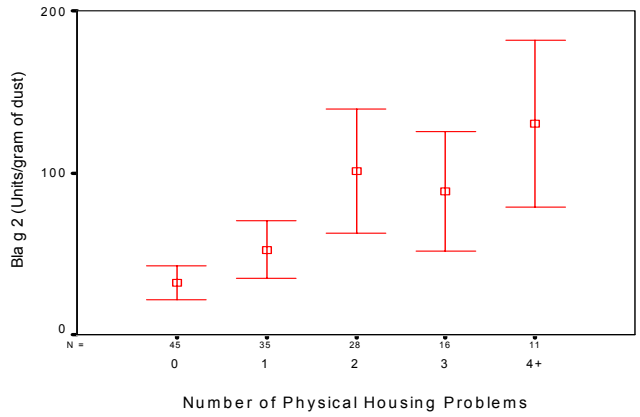
As part of the Columbia University Children's Environmental Health Center study of the impact of air pollution on child health (NIH: ES-97-004; P.I., Perera), we explored the links between cockroach allergen levels and selected housing characteristics; specifically, evidence of amount and type of disrepair. We did not focus on extreme conditions, but rather the relatively widespread aspects of disrepair such as cracks in ceilings and walls, leaky pipes, unrepaired water damage, inadequate/irregular heating supply, peeling paint, etc.—conditions that are part of the everyday lives of children who reside in underprivileged communities. The cockroach species of interest was Blatellla germaica (german cockroach) because of its well-known associations with asthma symptoms. Since the residential environment has both social and physical dimensions, we also measured the stability of the residential environment to explore how physical and social risk factors work together to determine allergen levels in house dust samples.

Dust borne allergen samples were collected from the homes of 132 pregnant women participating in the large cohort study within the Children's Environmental Health Center (refs). The target area for the Columbia University Children's Environmental Health Center includes the Northern Manhattan communities of Central Harlem, Washington Heights/Inwood, and the South Bronx**.** Although these three contiguous communities are predominantly low-income, they are distinct in racial/ethnic

composition, culture, residential history, housing characteristics, resources, and problems. Perhaps more so than most other relatively poor communities, the residents are exposed to a disproportionate share of environmental hazards, ranging from those within the home and the housing itself, to a myriad of neighborhood-based exposures, including physical environmental pollutants and aversive social conditions. Again, despite the relative impoverishment and high level of risk that characterize the entire study area, there is striking variability among the three geographically defined communities with respect to the physical and social environment, as well as historical context.

For the present analysis, the kitchen was selected as the monitoring site. Degree of housing disrepair was defined by the total number of adverse indoor housing problems, including: holes in ceilings or walls, peeling or flaking paint, water damage, leaking pipes, and lack of gas or electricity in past six months. Housing instability was treated as a dichotomous variable, scored as unstable if the target family had moved within the past year and had resided at the previous residence for less than two years. Results showed that maternal reports of cockroach sightings increased significantly with level of housing disrepair.

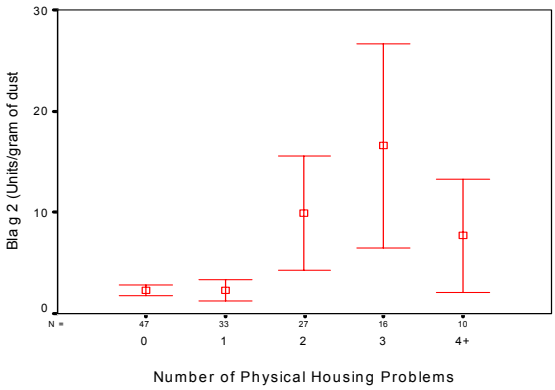
Figure 3. Mean and Standard Error of Cockroach Allergen in Kitchens (N=135) as a Function of Physical Housing Problems



Rauh et al., 2002, EHP, 110 (suppl 2):323-327.

Figures 3 and 4 present the results of multiple regression analyses predicting the mean natural log of Blag2 in the kitchen and the bedroom, respectively, as a function of housing disrepair, adjusted for income, ethnicity, crowding and moves. Level of disrepair and housing instability were independently associated with allergen levels. The addition of a variable indicating the number of pest control measured used in the home did not alter the magnitude of the coefficients for kitchen or bedroom. The main effect of disrepair was not explained by ethnicity, per capita income, or other available structural parameters of the built environment (floor lived on, number of floors in the building, presence of a basement, or restaurant nearby). Likewise, cleaning methods and use of pesticides were not significantly associated with allergen levels.

Figure 4. Mean and Standard Error of Cockroach Allergen in Bedrooms (N=133) as a Function of Physical Housing Problems



Rauh et al., 2002, EHP, 110 (supplI 2):323-327.

A final point concerns the role of housing as a potential agent of change or a focus of intervention aimed to reduce the harmful effects of environmental pollutants. Can interventions to correct the inadequacies of the residential environment reduce the prevalence of childhood asthma and developmental deficits? We know that lots of factors can be affected by policy, such as where to build a housing project, enforcement of municipal codes, rehabilitation of existing residential units, dispersal of the disadvantaged, etc., yet we do not know if such interventions will improve child health. For example, residential management of public housing may increase housing stability, tenant buy-outs may increase home ownership and commitment, and rehabilitation of existing residential units and strict code enforcement may prevent physical deterioration. However, the links between such community-level interventions, reduction in exposure to toxicants, and real child health improvements at both the individual and the group level remain to be studied. As recently advocated by the U.S. Surgeon General, one of the best community-level strategies to reduce the impact of hazardous pollutants is the *prevention* of inappropriate and environmentally unjust siting of pollution sources (conference sponsored by the Columbia Center for Children's Environmental Health, entitled 'The Health of Our Children in the Urban Environment', March 27, 2000).

References:

Chew GL, Higgins KM, Gold DR, Muilenberg ML, Burge HA. Monthly measurements of indoor allergens and the influence of housing type in a northeastern US city. Allergy. 54(10):1058-66 (1999).

Fullilove MT. Psychiatric implications of displacement: contributions from the psychology of place. Am J Psychiatry 153:1516-1523 (1996).

Gelber LE, Seltzer LH, Bouzoukis JK, Pollart SM, Chapman MD, Platts-Mills TAE. Sensitization and exposure to indoor allergens as risk factors for asthma among patients presenting to hospital. Am Rev Respir Dis 147:573-8 (1993).
Goldstein IF, Reed CE, Swanson MC, Jacobson J. Aeroallergens in New York inner city apartments of asthmatics. Adv. Aerobiol. 51:133-8 (1987).

Jones AP. Asthma and domestic air quality. Social Science and Medicine. 47(6):755-64 (1998).
Mayer S, Jencks C. Poverty and the distribution of material hardship. The J of Human Resources 88-112 (1998).

Mendoza F, Ventura S, Valdez B, et al. Selected measures of toward a social ecology of health promotion. Am Psychol Jan:6-22 (1992).

Perera FP, Jedrychowski W, Rauh VA, Whyatt RM. A molecular epidemiologic research on the effects of environmental pollutants on the fetus. Environmental Health Perspectives, 107 (Supplement 3): 451-460 (1999).

Perera FP, Illman SM, Kinney PL, Whyatt RM, Kelvin EA, Shepard P., Evans D. Fullilove M, Ford JG, Miller RL, Meyer I, Rauh V. The challenge of preventing environmentally-related disease in young children: community-based research in New York City. Environmental Health Perspectives, 110(2):197-204 (2002).

Platts-Mills TAE. How environment affects patients with allergic diseases: Indoor allergens and asthma. Ann Allergy 72:381-4 (1994).

Pollart SM, Chapman MD, Fiocco CP, Rose G, Platts-Mills TAE. Epidemiology of acute asthma: igE antibodies to common inhalant allergens as a risk factor for emergency room visits. J Allergy Clin Immunol 83:875-82 (1989).

Rauh VA, Chew G, Garfinkel R. Deteriorated housing contributes to high cockroach allergen rates in inner-city households. Envir Health Perspectives110 (suppl 2):323-327 (2002).

Rosenstreich DL, Eggleston P, Kattan M, Baker D, Slavin RG, Gergen P, Mitchell H, McNiff-Mortimer K, Lynn H, Ownby D, Malveaux F. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. N. Engl. J. Med. 336:1356-63 (1997).

Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multi-level study of collective efficacy. Science. 277:918-924 (1997).

Sarpong SB, Hamilton RG, Eggleston PA, Adkinson FN. Socioeconomic status and race as risk factors for cockroach allergen exposure and sensitization in children with asthma. J. Allergy Clin. Immunol. 97:1393-401 (1996)

Shiono PH, Rauh VA, Park M, Lederman SA, Zuskar D. Ethnic differences in birthweight: the role of lifestyle, social, psychological, medical, and other factors. American Journal of Public Health, 87:787-793 (1997).

Sporik R, Holgate ST, Platts-Mills TAE, Cogswell JJ. Exposure to house dust mite allergens (Der p I) and the development of asthma in childhood: A prospective study. N Engl J Med 323:502-7 (1990).

Wallace R, Fullilove MT, Flisher AJ. Aids, violence and behavioral coding: information theory, risk behavior and dynamic process on core-group sociographic networks. Social Science and Medicine. 43(3):339-52 (1996).

Design As If People Mattered: Fostering Health and Productivity in the *Built Environment*

Alexis Karolides,
Rocky Mountain Institute

"Man vs. Nature." We talk of conquering nature, as if "we" were somehow separate from "her." Realizing that we *are* nature would go a long way in helping us realize our dependence on earth's ecosystem services and the importance of protecting and enhancing, rather than "conquering" them. Bioshpere II was a $200 million project to scientifically replicate Bioshpere I, our earth. All the ecosystem services of earth were supposed to function under a series of glass domes where eight scientists were to live for two years. But long before the two years were up, the oxygen levels inside this manufactured biosphere had dropped to levels equivalent to Everest Base Camp, and were getting worse—even 200 million dollars couldn't replicate the simple ecosystem services that Bioshpere I provides for us every day—ostensibly, for free. Our best technologies can't substitute for water and nutrient cycling, atmosphere and ecological stability, pollination and biodiversity, topsoil and biological productivity, or the ability to assimilate and detoxify society's wastes. These services underpin all life and thus economic activity. There is no longer any serious scientific dispute that every major ecosystem service in the world is in decline. With 10,000 new people arriving on earth every hour, more people are chasing after fewer resources. The limits to economic growth are coming to be set by scarcities to natural capital, by fish rather than boats, forests not saw-mills. Sometimes it is only when ecosystems fail that we recognize their value. In 1998, floods in China's Yangtze basin, a $30 billion disaster, inundated 60 million acres of land, killing 3,700 people and dislocating 233 million. China, realizing that the flood was a result of massive deforestation upstream, instigated a $12 billion crash reforestation problem to avoid repeat occurrences.

How does this relate to our built environment?

Buildings and Building Materials
The fact that we build shelters for ourselves is no more unnatural than a fox digging a den or a termite colony building a mound. The real question is, are our structures *well-adapted for life on earth in the long run?* Perhaps, instead of trying to conquer nature, we should apprentice with her. Designs in nature have undergone 3.8 billion years of rigorous testing. Only one percent of species that ever existed are still with us today—the rest were "recalled by the Manufacturer." Industrialism's approach to making materials is to "heat, beat, and treat." Nature—at least the one percent of species that have survived evolution—abides by two simple rules: maximize resource efficiency and support the surrounding environment. This means using local materials, using as little energy as possible—all from current solar income, and creating no waste—everything "discarded" by one organism must be food for another. It also means creating no toxicity, fostering biodiversity and practicing cooperation. (If we think that the natural world is completely competitive, consider a mature forest, where large trees that block out the light from smaller trees actually share nutrients with them through interlinking root systems.)

Engineers and material scientists would do well by using nature as a design mentor. Take the ceramics industry, for instance and compare it to the Abalone shell. To form its shell, the Abalone excretes proteins that assemble an electrically charged framework on which seawater deposits minerals forming

a crystalline inner shell twice as strong as our ceramics—all accomplished in ambient temperature water with zero waste. In some instances human engineers have looked to nature for design solutions. Termites in Africa, Australia and the Amazon build 30-foot mounds that are passively air-conditioned by passages in walls as hard as concrete but made of earth, wood bits and termite saliva. The Eastgate building in Harare, Zimbabwe is completely passively cooled using a system that was directly modeled on the termite mound. Biological wastewater treatment is another example. Dr. John Todd studied how nature purifies waste and created the Living Machine™, which turns sewage into clean water and flowers by flowing it through a series of aquaria filled with living organisms. And William McDonnough used the natural model of zero toxicity when he designed a fabric for DesignTex™. Eight thousand chemicals were tested as candidates for cloth treatment and coloring and McDonough's team chose from the mere 38 that were found to be nontoxic. The fabric was manufactured in Swiss factories, where environmental regulators thought that their equipment for testing the plant's effluent had malfunctioned—the water coming out of the plant was cleaner than the water going in. As McDonough says, "We must take the filters out of the pipes and put them where they belong—in the designers' heads."

The ING Bank in Amsterdam is an example of a building that was designed from the start with the long-term well-being of people in mind. In 1978, the bank was suffering from a stodgy, conservative image and their market share was slipping. Their new headquarters building was to address this problem. The designers were to meet just two criteria. First, the building was to be organic, filled with light, air, plants, water, art, and happy employees. Second, the building was not to cost one guilder more per square meter than conventional construction. An integrated team approach was used to meet both criteria. The resultant building sits on its parking, harvests its rainwater, uses active and passive solar collectors and passive cooling with backup absorption chillers and it has operable windows and non-toxic materials. Artwork (metal panels in the atria) doubles as a daylighting device, reflecting light up to 1-1/2 stories deeper into the building. Water gurgles down the center of the stairwell handrails, providing white noise in a building that would otherwise be *too* quiet, without the constant noise of mechanical systems. The combination of all these systems slashed the building's energy use, saving 90 percent of the energy used by the former building, equating to dollar savings $2.9 million annually (a three month payback). But even more important, absenteeism dropped by 15%. Why is this so critical? According to data from Building Owners and Managers Association, the average amount of money spent in an office building in the United States (in 1991) for energy was $1.81 per square foot and for rent, $21 per square foot. But office workers' salaries come to over $130 per square foot. Based on these numbers (when insurance, taxes and other benefits are factored in), a mere one percent increase in worker productivity can pay for the entire energy bill of the building.

It is not surprising that enhancing indoor environmental quality improves occupant performance and health. The indoor environment is enhanced by "green building" features, including quality lighting with high levels of daylighting, increased individual control of the workplace (lighting, temperature, ventilation), improved acoustics, better air quality and a connection to nature. A study by the Heshong Mahone Group in 1999 found that students in daylit schools progresses 20-26 percent faster on test scores and have better attendance than students in schools without daylighting. In a companion study, Heshong Mahone found that daylit retail stores realize an increase in sales of up to 40 percent. It works for industrial buildings as well. The Verifone company in Irvine, California saw a 47 percent drop in absenteeism when they retrofit an old building with daylighting, a double-filtered air supply and non-toxic materials.

Studies have also shown a direct correlation between contact with nature and enhanced human well being. For instance, a study by Margaret A. Ovitt in 1996 found that ICU nurses had lower stress levels if their break room had views of nature. A study by R.S. Ulrich in 1984 documents that patients recovered faster and needed less medication when their hospital window faced trees rather than a brick wall.

Communities

Designing for people also means designing livable communities. Typical tract home developments drain storm water in expensive underground sewers. Village Homes, an early solar housing development in Davis, California, instead installed natural drainage swales. This saved $800 per house, and provided more green space. They then used the saved money to pay for extensive edible landscaping that provided shade, nutrition, beauty, community focus, and crop revenues to support more amenities. The landscaping plus people-centered site planning (pedestrian/bike greenways in front of the houses, cars around the back, narrow, tree-shaded roads) saved more land and money. It also created safe and child-friendly neighborhoods that cut crime 90%. Real estate brokers once described the project as weird. It is now the most desirable real estate in town.

For communities to remain livable, they must enhance their natural capital. This can be as simple as replacing the acres and acres of non-native monoculture turf grass that cover our corporate and institutional campuses and our residential lawns with the native vegetation that once grew there. When landscape architect Jim Patchett replaced 50 acres of turf with native prairie on AT&T's Lisle, Illinois campus, maintenance costs dropped from $2,000 to $500 per acre. Irrigation, pesticides, fertilizers and herbicides were no longer needed and the natural ecosystem provided free stormwater management as well. Providing a living roof atop a building more than doubles the life of the roof (by blocking damaging UV light), reduces storwater runoff, enhances insulation value, lowers the ambient air temperature (by reducing radiation from the roof), improves air quality, increases wildlife habitat, and adds beauty.

Cities

Finally, entire cities should be designed for people. If we think this is too difficult a task to take on, consider Curitiba, Brazil, not a rich city, but one of the world's great cities nonetheless—by design. As Curitiba's population quadrupled to 2.5 million, the then Mayor, Jaime Lerner, led the city to undertake a whole-systems urban design overhaul. Social, economic and ecological issues were seen, not as competing priorities to be traded off, but as interlinked design elements with synergies to be captured. For instance, in squalid makeshift neighborhoods where alleys were too small for trash collection trucks to drive through, the city instigated a food-for-trash program. If residents brought their trash to the edge of the community, they were given fresh vegetables in exchange. This cleaned up the trash in the streets and was the *least expensive method* of doing so. The city's transportation system was seen as a way to move people as well as a way to guide land-use and to control growth patterns. Too poor to build a light rail system, the city created a bus system that is widely believed to be the best in the world. Designated bus lanes and platforms at bus level that allow passengers (who have already paid their fares when they entered the platform) to glide onto the bus through several doors are some of the features that have made it possible for this bus system to achieve three times the average passenger-transport per hour and three times the average speed of a traditional bus system. Flood control was also seen as a way to provide an amenity for people while enhancing the environment. Riparian zone protection laws created parks along riverways, new lakes became the core of new parks and now, when the city experiences heavy rains, the engineers quip that it just means the

ducks in the parks float a meter higher than usual. These natural strategies stopped the flooding and cost far less than traditional “hard-engineered” methods. Finally, community solidarity was enhanced. Through patient negotiation (without police involvement), gangs that had vandalized daycare centers and the new botanical garden ended up getting involved in the work of these facilities. The vandalism stopped as the young people took ownership in the daycare and gardening activities.

In summary, a built environment that is better for the long-term health of the surrounding ecosystems that provide our life-support systems, is also better for human health and productivity. My three recommendations are (1) to design buildings as integrated whole systems that are resource-efficient and foster indoor and outdoor environmental quality, (2) to design communities that foster social interaction and enhance natural ecosystems while providing community amenities, and (3) to design whole cities as integrated systems, solving multiple problems at once while benefiting social, cultural and environmental factors.

Health Impacts

Air Pollution and Its Health Effects

George Thurston,
New York University

Past air pollution episodes and recent epidemiological and toxicological studies have indicated that air pollution can cause significant adverse human health effects. Over the past few decades, medical researchers examining air pollution and public health, including myself, have shown that air pollution is associated with a host of serious adverse human health effects. Two of the key air pollutants that have been associated with adverse health effects that are caused by emissions from the Built Environment, including power generation and motor vehicle emissions, are Ozone (O_3) and Particulate Matter (PM).

Ozone (O_3) is an invisible irritant gas formed in the air in sunlight from other air pollutants, including nitrogen oxides and hydrocarbons. These "precursor" pollutants, which cause the formation of ozone, are emitted by many pollution sources, including motor vehicles, electric power plants, and industry.

Particulate Matter air pollution is composed of two major components: primary particles, or "soot" and "ash", emitted directly into the atmosphere by pollution sources such as industry, electric power plants, diesel buses, and automobiles, and; "secondary particles" formed in the atmosphere from gaseous pollutants such as sulfur dioxide (SO_2), and nitrogen oxides (NO_X). Sulfur dioxide emissions from coal plants contribute the most to secondary particle formation. Sulfur dioxide is chemically converted in the atmosphere after it is released from a smokestack to become a "sulfate" particle. Sulfates include sulfuric acid particles that not only form acid rain but, when inhaled, can reach deep into the human lung.

Observational epidemiology studies have shown compelling and consistent evidence of adverse effects by ozone and PM. Such scientific studies statistically evaluate changes in the incidence of adverse health effects in a single population as it undergoes varying real-life exposures to pollution over time, or across multiple populations experiencing different exposures from one place to another. They are of two types: 1) population-based studies, in which aggregated counts of effects (e.g., hospital admissions counts) from an entire city might be considered in the analysis; and, 2) cohort studies, in which selected individuals, such as a group of asthmatics, are considered. Both of these types of epidemiologic studies have shown confirmatory associations between O_3 and PM air pollution exposures and increased adverse health impacts, including:

- decreased lung function (a measure of our ability to breathe freely);
- more frequent respiratory symptoms;
- increased numbers of asthma attacks;
- more frequent emergency department visits;
- additional hospital admissions, and;
- increased numbers of daily deaths.

The people most affected by ambient air pollution include: older adults persons with pre-existing respiratory disease (e.g., chronic obstructive pulmonary disease, COPD, such as emphysema),

children, especially infants and those with asthma, healthy adults who work or exercise outdoors, and persons with inadequate health care, such as the poor and working poor.

Fine particles (those less than 2.5 micrometers in diameter, or PM2.5), such as those that result from power plant and motor vehicle emissions, can bypass the defensive mechanisms of the lung, and become lodged deep in the lung where they can cause a variety of health problems. Indeed, the latest evidence indicates that short-term exposures cannot only cause respiratory damage, but also cardiac effects, including heart attacks. Moreover, long-term exposure to fine particles increases the risk of cardiac, respiratory and lung cancer death and has been estimated to take years from the life expectancy of people living in the most polluted cities, relative to those living in cleaner cities.

The hazards of fine PM have become particularly clear in the past decade's research. Two of the largest landmark studies on particulate matter and death, the Harvard Six Cities Study, published in 1993, followed by the American Cancer Society (ACS) Study in 1995, demonstrated greater risk of premature death from particulate matter in more polluted cities, as compared to cities with cleaner air (Dockery et al, 1993; Pope et al, 1995). Fine particles, especially sulfates, were most strongly associated with excess mortality in polluted cities. The ACS study examined half a million people in over 150 metropolitan areas throughout the United States and found a 17 percent greater risk of mortality between the city with the least sulfate and particulate matter and the city with the highest levels of this particulate pollution. The results of these studies were challenged by industry, resulting in an independent reanalysis by the Health Effects Institute (HEI)—funded by industry and EPA. HEI confirmed the associations found by the original investigators. Furthermore, a recent National Institute of Environmental Health Sciences (NIEHS)-funded extension of the ACS study ((Pope, Burnett, Thun, Calle, Krewski, Ito and Thurston, 2002), strengthens the original conclusions of the ACS study and now links increased risk of lung cancer to long term exposure to particulate matter and sulfate air pollution.

Overall, outdoor air pollution increases the incidence of health problems experienced by the public, especially among under-served minorities and the poor. Transportation and power generation are major causes of air pollution health impacts Thus, reducing pollution can improve health and reduce health disparities. In the future, there is a need for investigations that quantify the air pollution and health benefits of better planning (e.g., reducing urban sprawl), and that quantify the air pollution and health benefits of more efficient and cleaner energy technology; Once health benefits of improved urban planning and energy efficiency are known, policy makers and the public will be more likely to support societal action on these issues.

REFERENCES

Dockery DW, Pope CA 3rd, Xu X, Spengler JD, Ware JH, Fay ME, Ferris BG Jr, Speizer FE. An association between air pollution and mortality in six U.S. cities. N Engl J Med. 1993 Dec 9;329(24):1753-9.

Pope CA 3rd, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE, Heath CW Jr. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. Am J Respir Crit Care Med. 1995 Mar; 151(3 Pt 1): 669-74.

Pope CA III, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, and Thurston, GD. (2002). Lung Cancer, Cardiopulmonary Mortality and Long-Term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association* (JAMA). March 6, 2002, Vol. 287, No. 9, pp. 1132-1141.

Measuring Relationships Between Urban Form, Physical Activity Levels, and Public Health

Lawrence Frank,
Georgia Institute of Technology

Introduction

The design of the built environment impacts how we travel, spend our time, how much we pollute and the quality of the air we breathe, and the cleanliness of the water we drink. These factors in turn impact public health. Historically, the design and function of our cities was understood to be a health concern. Frederick Law Olmstead, designer of New York's Central Park and many other major public spaces of the 19th and 20th Century American City, was a sanitary engineer. In the 18th Century, Napolean's City Planner Houssman raised vast corridors of Paris to increase the flow of air while also facilitating better movement for transportation and military purposes. Modern zoning and subdivision regulations in America are legally underpinned based on the ability to demonstrate the health, safety, and welfare benefit of specific land use actions. Therefore, the nexus between urban form and public health is recognized, but its importance is both underestimated and perhaps even poorly understood.

Unfortunately, a modern reductionist approach to the formation of specialized professions adopted in western civilization has given rise to a narrowness of focus that facilitates the ability to miss important linkages across disciplinary boundaries. In simple terms, the bridge between urban planning and public health is obvious and even recognized in certain legal contexts. However, both professions have developed their own paradigms and pedagogical frameworks without sufficient recognition of the other. This lack of integration between city designers and planners and public health is glaring given that most people recognize what is a safe and inviting place to walk, and what is not. Many also recognize the importance of walking and biking as efficient forms of physical activity.

Research shows alarming increases in obesity amongst the U.S. populace in recent decades (Mohkdad et al, 2000). Emerging research suggests that this lack of physical activity associated with an auto dependent urban form is partially responsible for this trend. While the science is surely in its infancy, these relationships between city form and public health are somewhat intuitive. What is required is the reconstruction of a bridge at both policy and applied research levels between the physical environment and public health. Such a bridge needs to span complex sets of influences at play within the fields of environmental planning, architecture, transportation, and health. An inspirational symbol of such a bridge is warranted. The *Pont Du Guard* was built by the Romans in Provence, France near the time of Christ. It is often speculated that this wonder of engineering, set with laser precision at a half of one percent slope as an aqueduct, will outlast bridges being opened today.[1] The past offers us many lessons in the arena of how to shape settlement patterns to meet the needs of human health. Relearning these lessons will be important to the sustainability of our society and our environment.

[1] Recent floods nearby in Vaison La Romaine France resulted in the destruction of nearly all the bridges in that region except the one ancient Roman bridge.

Trends in Travel and Time Use

Between 1970 and 1996 U.S. population grew 30 percent, drivers grew 60 percent, registered vehicles grew by 90 percent, and miles driven grew by 123 percent (U.S.A. Today). Collectively, Atlantans travel further than the distance to the sun each day. In this region, time spent in congestion for the average resident increased from 11 hours in 1982 to 53 hours in 1999 (Texas Transportation Institute, 1999). An increase in travel and time use of this magnitude devoted to the car has significant implications on the health and activity patterns and the usage of time for residents of the modern American metropolis.

How and *Where* Both Matter

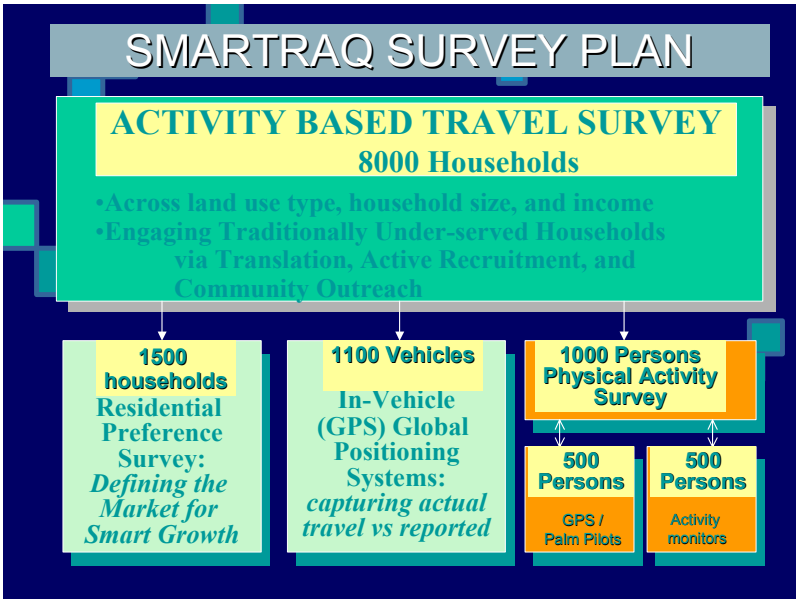
While the design and form of development is critical to the patterns of activities observed from a given household (how); the location (urban center, suburban, or outlying exurban area) of the household within a regional context is also critical (where). Residents of walkable environments, in terms of being pedestrian friendly and mixed use, may still need to spend large amounts of time getting to and from work if they are located at the periphery of an urban region without major employment opportunities nearby. Research demonstrates that the level of street connectivity[2] where one lives is inversely associated with the amount of miles traveled and the amount of harmful vehicle emission produced per household (Frank, Stone, and Bachman, 2000). Additional research is also presented that demonstrates that residents of newer developments on average generate fewer non-motorized trips and travel further to recreate (Frank, 2000). These findings are significant because they suggest that the age of development is a meaningful surrogate for the independent environmental factors that impact household behavior. These findings are further supported with recent findings using the CDC's NHANE's dataset whereby age of housing was correlated with self reported levels of physical activity (Berrigan, 2002).

SMARTRAQ Program

While these findings are useful for understanding that there are likely to be systematic linkages between important predictors of public health and urban form, primary data collection is required before appropriate interventions can be detected. The Atlanta based Strategies for Atlanta's Regional Transportation and Air Quality (SMARTRAQ) research program (see www.smartraq.net) has been designed to collect information on urban form and public health in such a manner to support this level of inquiry. SMARTRAQ is funded by the Georgia Department of Transportation, Georgia Regional Transportation Authority, Centers for Disease Control and Prevention, Environmental Protection Agency, and others. As shown in Figure 1, SMARTRAQ includes a(n):

[2] The number of intersections per square kilometer which captures one can traverse between trip origins and destinations in a straight line.

Figure 1 – SMARTRAQ Progam Structure



- 8000 household / 17,500 participant activity based travel survey with demographics, attitudinal variables, and other predictors of public health including BMI;

- Physical activity sub-survey of approximately 800 households capturing levels of social interaction and isolation and time use across different types of moderate and vigorous physical activities, objective measures of physical activity from the deployment of accelerometers, and on person travel diaries and GPS devices; and

- Urban form measures for all households and participants calculated at the disaggregate – or household specific level.

Preliminary findings from SMARTRAQ suggest increases from a BMI of around 25.5 to a BMI of around 26.5 between residents of the highest and the lowest respective residential density environments in that region. A significance level (P=0.00) was found between BMI, net residential density[3] and intersection density after controlling for age, income, and other demographic factors (Frank, Schmid, and Engelke, 2002). While further investigation will no doubt be applied to these data including non-parametric tests and other non-linearity tests and forms of regression analysis, these are the first findings to indicate that dwellers of more compact and interconnected environments are, on average, thinner. All else being equal, these findings support the hypothesis that an increased ability to walk to accomplish our daily activities is health promoting -- especially "at the margins."

The Neighborhood Quality of Life Study (NQLS)

The Neighborhood Quality of Life Study (NQLS), being led by Dr. Jim Sallis (PI), Dr. Lawrence Frank (Co-PI), and Dr. Brian Saelens (Co-PI) is a National Institutes of Health funded four year study

[3] Net residential density is defined here as the number of households per land area devoted to residential use within a one kilometer network distance from where one lives.

to test the effects of urban form on objective measures of physical activity in thirty-two communities in the Seattle and Baltimore Regions.

NQLS has this primary and secondary aim:

- *Primary Aim* -- To document the association of neighborhood environment characteristics (density, connectivity, mixture of land use) with objectively measured physical activity. Investigate whether people living in more "walkable" communities are more physically active, after adjusting for socio-demographic variables.

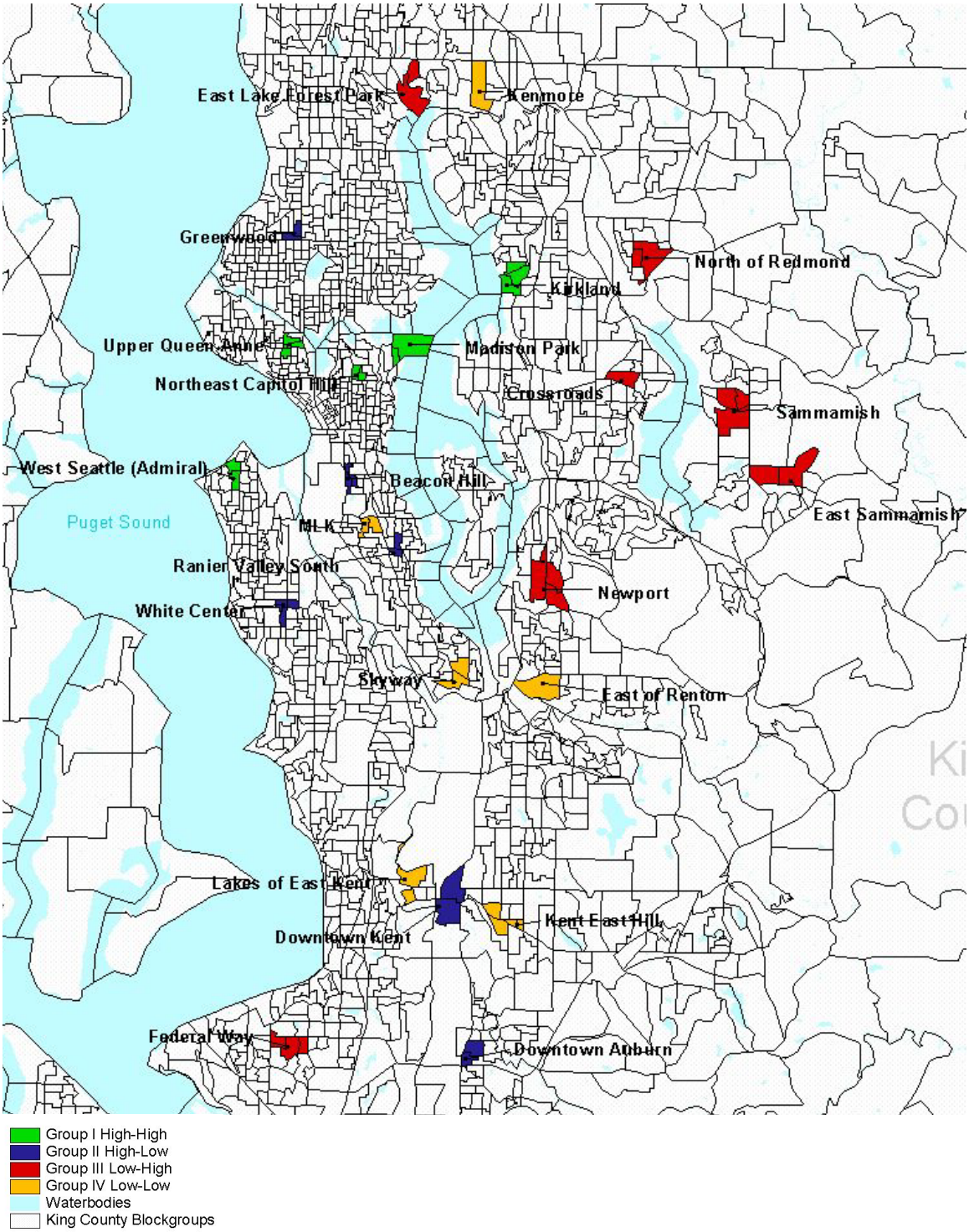
- *Secondary Aim* -- Compare the relative contribution of perceived versus objective environment to the explanation of physical activity.

In each region, eight walkable and eight non walkable communities are selected for the recruitment of 100 households. A systematic process has been employed to select communities based on the creation of a walkability index use to measure the level that the built environment supports non-motorized accessibility at the Census block group level. Block groups are also matched based on census data on income, age, and educational attainment. A goal of approximately twenty five percent of the observations being non-white is being met for the Seattle region and will be met in the Baltimore region as well. Participants complete surveys and wear accelerometers for two separate survey weeks of observation. These two one-week periods are separated by several months. Figure 2 conveys the 16 communities that have been selected for the NQLS study using this process.

Implementing Smart Growth in King County Washington

Where SMARTRAQ and NQLS emphasize research and measurement, King County is funding a program that focuses on the ability to develop research and to apply the findings from this research within specific communities countywide. This study leverages significant land use, health, and travel data already existing in the Central Puget Sound Region. This King County Program is funded by the Federal Transit Administration (FTA) and has some additional funding provided from the Centers for Disease Control and Prevention. This is one of the first studies of this nature being led by a major local government. Typical of local governments, King County controls the use of land, but King County also is the primary regional provider of transit and therefore, oversees the allocation of transit service hours, along with highway, and pedestrian investments. The King County study has important linkages with the NQLS study. Three of the 16 NQLS communities shown in figure 2 (White Center, Kent East Hill, and Redmond) are the case study locations where King County will be piloting various interventions that are drawn from the research. This integrated design enables these two studies to leverage their resources and to integrate the collection of physical activity, travel, and urban form data at the community level. This is the first time that this level of integrated community level data collection has been conducted across these disciplines.

Figure 2 – Selected Communities for the Seattle Region



ConclusionThrough the integration of research programs and the design of primary datasets that bring together public health and urban form; it will become possible to gain a better understanding of the types of interventions that will best achieve commonly held goals of increased physical activity, reduced air pollution, and more efficient usage of our natural resources. The King County Study is embarking on the collection of community level travel and activity data. The NQLS study is collecting objective measures of urban form in these communities as well. Collectively, these datasets will provide a robust set of indicators in a pre-test fashion. These data provide a baseline of conditions that can be revisited after certain changes to the built environment are implemented in these communities through follow-up post-test survey research.

This type of pre-test – post-test research at the community level is required to systematically evaluate the effectiveness of various interventions designed to promote increased levels of physical activity. Improvements to the pedestrian infrastructure alone may not be sufficient to stimulate increased walking for utilitarian purposes. What is required is the contemporaneous increase in levels of land use mix to support shorter distances between where we live, work, and play. Increased density of development is also fundamental to justify transit investments. Given a choice, households will not choose to trade off auto ownership and use without both regional mobility provided through transit and local accessibility provided through a high quality pedestrian environment. SMARTRAQ, NQLS, the King County study can inform which investments make sense in specific urban form contexts to promote our health and the integrity and sustainability of the built environment.

Inter- and Intra-Ethnic Variation in Water-Related Exposures and Environmental Risk Perception Among Tucson Residents: The Role Of Culture & Environmental Equity

Bryan Williams,
University of Arizona

Little is known about the impact of the "built" environment on our nation's Mexican-American population. Although there is evidence of considerable environmental inequity and morbidity among this population, we do not know how such inequity influences their behavior, their perceptions, and ultimately their health. For example, to what extent does the reality or perception of poor water quality influence water consumption patterns among Mexican-Americans? Or, to what extent does living in less than optimal physical environment influence Mexican-American's perception of environmental risk? Reducing environmental risks among this population necessitates that we better understand these behaviors and perceptions. The purpose of these studies was to examine the inter- and intra-ethnic variation in drinking water consumption and environmental risk perception among Tucson residents. Additionally, this investigation also delineated the degree of environmental inequity among this population in relation to the built environment.

The Built Environment for Tucson's Mexican American Population

Clearly, the built environment is less than optimal for most Mexican-Americans living in Tucson. Like other ethnic minority populations, Tucson Mexican-Americans face several glaring economic and environmental realities. First, they are substantially more impoverished and less educated than Caucasians living in the city (U.S. Census, 2000). Second, they are disproportionately exposed to various environmental contaminants (Lebowitz, et al., 2000; O'Rourke and Lebowitz, 1999). In fact, ethnic minority populations living in Tucson are 5 times more likely than Caucasians to live near a Superfund site and 3.6 times more likely to live near a facility that emits criteria air pollutants. Additionally, Mexican-Americans may be receiving lower quality tap water than are Caucasians living in Tucson (Louchouarn and Williams, 2002). Finally, environmental racism poses a serious concern in Tucson. Clarke and Gerlak (1998) argue that environmental inequity represents an inexorable reality for Tucson's "forgotten southsiders". Their plight has even warranted the concern of the Institute of Medicine (IOM, 1999). Such inequity appears to have influenced this population substantially.

Water Intake and Source Patterns Among Mexican-Americans

Direct water intake and source patterns were examined among non-Mexican whites and Mexicans living in the Tucson metropolitan area. Using random digit dialing, researchers conducted a cross-sectional telephone population survey of 1,183 Tucson residents. Significant ethnic variation was observed in water intake patterns among this sample, particularly in terms of source. Mexicans reported much higher rates of bottled water consumption than did non-Mexican whites. Ethnic variation in exposure parameters such as that observed in this study increases the potential for measurement error in exposure analysis. Erroneous assumptions that exposure estimates (i.e., water intake source) are generalizable across various ethnic groups may lead to both overestimation and underestimation of contaminant exposure.

Environmental Risk Perceptions Among Tucson Mexican-Americans

The environmental perceptions of our nation's Mexican and Mexican American population, especially in the area of water quality, can help explain the differences found in water consumption patterns. We examined these perceptions to determine the extent to which Caucasians and Mexican Americans living in the Tucson, Arizona, metropolitan area differ in their perceptions of water quality–related risk, inequity, trust, and participation in civic activities. Ethnic variations in perceptions toward inequity, trust, and public participation were observed even when socioeconomic variation between Caucasians and Mexican Americans was controlled. However, significant ethnic variations in perceptions of water quality–related risks were observed only when socioeconomic variation was not controlled.

Significantly heightened perceptions of water quality–related risks were observed among Mexican Americans only when the socioeconomic variables of income, education,
and length of residence were ignored. When we controlled for these variables, perceptual differences between the two groups were no longer significant. They also reported surprisingly high levels of institutional trust despite the inequitable conditions of their communities. Mexican American respondents were even more trusting of environmentally related institutions than Caucasians who live in arguably more environmentally friendly communities. A high level of institutional trust among economically disadvantaged groups is uncommon.

Policy Implications for Differential Exposure to Water

Knowing that Mexican-Americans perceive their risks of consuming tap water to be higher than Caucasians, and that their exposure to environmental risks in general are higher than Caucasians, what are the policy implications? First, it is necessary to determine whether Mexican-Americans' different consumption patterns are associated with actual water quality problems. If so, what is the source of these contaminants? In Tucson, drinking water supplies come from underground aquifers. Tap water contaminants may be either naturally occurring in the soils and bedrock of groundwater basins (as would be the case with Arsenic and other regulated metals), or they may come from distribution systems, such as old lead pipes. Understanding the source of environmental contaminants then provides a basis for determining how to mitigate environmental risk inequities among Mexican Americans.

Recommendations

In light of these findings, it is clear that more research is needed to better understand the overall impact of the built environment on exposure, morbidity, and mortality among Mexican-Americans. My recommendations are threefold: First, use multi-level statistical models (i.e., hierarchical linear modeling) to determine the differential impact of homogenous community-level factors (i.e., distribution of environmental burdens) on cancer morbidity and birth outcomes. Second, given the observed variation among Mexican-Americans, we should obtain population specific time-activity data for all exposure assessments. Finally, we should examine the impact of acculturation on environmental perceptions and behaviors among Mexican-Americans.

References

Clarke JN, Gerlak AK. Environmental racism in the Sunbelt? A cross-cultural analysis. Environ Manage 22(6):857–867 (1998).

Goldberg SJ, Lebowitz MD, Graver EJ, Hicks S. An association
of human congenital cardiac malformations and drinking water contaminants. J Am Coll Cardiol 16:155–164 (1990).

Institute of Medicine. Toward Environmental Justice: Research, Education, and Health Policy Needs. Washington, DC: National Academy Press, 1999.

Lebowitz M.D., O'Rourke M.K., Rogan S., Reses J., Van de Water P., Blackwell A., Moschandreas D.J., Gordon S., and Robertson G. Indoor and outdoor PM10 and associated metals and pesticides in Arizona. Inhal Toxicol 2000: 12 (Suppl. 1): 139– 144.

O'Rourke MK, Lebowitz MD. Indoor bioaerosol contaminants.
In: Environmental Toxicants: Human Exposures and Their Health Effects, 2nd ed (Lippmann M, ed). New York:van Nostrand Reinholt, 1999;449–480.

U.S. Bureau of the Census. Census of Population and Housing for the State of Arizona. Washington, DC:U.S. Bureau of the Census, 2000

Partnerships for Environmentally Friendly Communities

The Built Environment: Health Damaging or Health Promoting

Robert Lawrence,
John Hopkins University

The built environment includes the physical alteration of the land and the structures created to produce, store, process, and distribute food. As the proportion of the American population working in the agricultural sector has declined with the mechanization of farming, the development of modern industrial agriculture has had profound impact on the environment and on the health of those engaged in agriculture. The emergence of industrial agriculture and industrial animal production after World War II replaced free-range animal production with concentrated animal feeding operations requiring large buildings housing hundreds of hogs or thousands of chickens or large open feedlots housing thousands of cattle. The built landscape has been altered by the construction of open basins or "lagoons" for storing hog feces and urine before applying the waste as fertilizer. The industrialization of agriculture with extensive monocropping and the geographic separation of grain and forage production from animal production and the separation of both from urban population centers has also contributed substantially to the transportation system because of the requirement to move food hundreds or thousands of miles from its production site to the marketplace. A recent study in Washington DC showed that the average item on the supermarket shelf had been transported over 1500 miles.

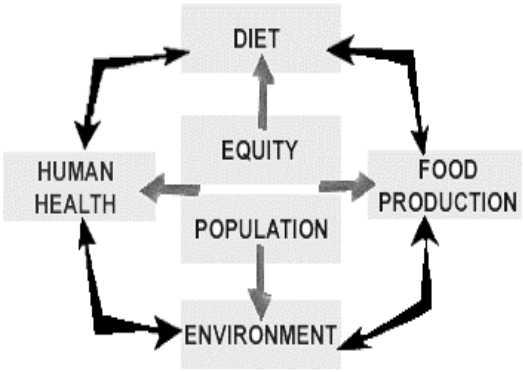
The modern industrial agriculture system developed to feed a growing population which was becoming more urbanized. Successful marketing practices have created the expectation that fresh foods in great variety would be available on the market shelf regardless of season and have taken expectations of the American people well beyond the concept of food security alone, although our current system does not provide for food security for all Americans.

Food Security is defined as, "Sustained access by all individuals to adequate and safe food for an active, healthy, and productive life."

UNDP Human Development Report 1998.

This definition of food security in the United Nations Development Programme Human Development Report, 1998 highlights the importance not only of adequate amounts of food but also food that is safe and provide nutrients for a healthy life. Producing that food for an increasing population worldwide and distributing that food equitably without damaging the environment requires new ways of thinking about the relationship between the built environment of industrial agriculture, the environment, and human health. Diet and food security, food production, health, and the environment are inextricably linked. These issues are the focus of the work of the Center for a Livable Future. While some of these connections have been know for a long time, others are only now being adequately understood. The diagrams below illustrate how these factors interact while being influenced by population pressure and the need to create more equity.

Diet, food production, human health, and the environment.



1. Diet and Human Health

Beginning about 80 to 90 years ago, an epidemic of heart disease began to sweep through the U.S. and other industrialized countries. A link between this epidemic and excess consumption of animal fat was established through a series of epidemiologic studies. Additional risk factors such as smoking, lack of exercise, and hypertension were documented in the Framingham Heart Study, a population cohort study that has shed much light on the relationship between diet and heart disease. The correlation between cardiovascular disease and specific lipids in the blood was established. The roles of both high blood levels of LDL (low- density lipoproteins) and low blood levels of HDL (high-density lipoproteins) have been further defined in many case control and cohort studies. Finally, intervention trials to test whether decreasing dietary saturated fats and lowering blood levels of LDL changed cardiovascular outcomes proved that such a dietary change was highly effective in reducing the incidence of cardiovascular disease.

2. Diet and Food Production

This link is less apparent, although what people eat determines what food is produced and how it is produced to meet growing demand. The annual consumption of 11 billion animals in the U.S. (35 million cattle, 100 million hogs, and over 10 billion poultry) contributes directly to the demand for expansion of industrial animal production. Recent demands for organic and sustainably grown foods led to a twenty-fold increase in organic food production in the last decade, demonstrating how demand patterns can influence food production methods in positive as well as negative ways.

3, Agriculture and Environment

The links between agriculture and environmental stewardship or degradation have been known for a long time. In 1990, Miller noted that deforestation, soil erosion, and overgrazing in 3000 BC converted the fertile land of Babylon to the desert of modern day Iraq.[4] This and other lessons go back to ancient times, but have been largely ignored in our contemporary agricultural policies and crop subsidy programs.

.

[4] From: "International Perspectives on Environmental Development: Toward a Sustainable World. Shahi GS, Levy BS, Binger A., Kjellstrom T, Lawrence RS. Springer, NYC (1997) p. 6.

4. Population and Food Security

The global population now exceeds 6 billion people, and more than 1.5 billion people lack food security. While many in the industrialized world consume excess calories, fueling the epidemic of obesity in the US and among the affluent even in developing countries, the 25 percent of the world's people who lack food security suffer from problems related to flawed agricultural policies and distribution barriers of political origin.

II. Nutrition, Health, Food Security, and Environmental Sustainability

The pattern of excess consumption of meat and animal products among the rich countries and wealthier individuals impacts health and the environment. A diet containing animal protein in excess of body needs not only contributes to chronic diseases but also wastes resources – water and land that could be used to grow food for humans.

In the book "Who Will Feed China," Lester Brown argues that the world's capacity to produce food will not be able to sustain the world's population if everyone consumes a diet similar to that of the average person in the US.[5]

The per capita consumption of grain per year varies in different countries because of the type of diet. The US has the highest grain consumption at 800 kg per year per capita. Italy and Taiwan are in the middle at 400 and 300 kg respectively. China is now at 250 kg per capita per year, but increasing rapidly with increased prosperity and increased consumption of pork and other meats. India at 200 kg per capita represents a diet barely adequate in protein and calories.

Grain consumption per capita per year

- USA 800 kg
- Italy 400 kg
- Taiwan 300 kg
- China 250 kg
- India 200 kg

What accounts for this two- to four-fold difference in the amount of grain needed per person in different countries? The amount and type of meat in the diet determines the total amount of grain needed to feed one person. The more meat in the diet, the more grain that person will consume per year since grain must be fed to cattle, pigs or poultry first. It is much more efficient for humans to ingest the grain protein directly.

Amount of grain needed to produce meat for human consumption.

- 700kg grain to produce 100kg of beef
- 450kg grain to produce 100kg of pork
- 300kg grain to produce 100kg of poultry

[5] Brown LR. "Who Will Feed China? World Watch, Washington, 1995.

Water use:
In addition to using land for growing grain for animals rather than directly for human consumption, 1000 kg of water are needed to produce 1kg of grain. In some places in the world where water is scarce, the use of water to produce animal protein is unsustainable. Ancient aquifers are being depleted to irrigate grain fields faster than they can be replenished. Is this a modern-day Babylon?

The average US adult male consumes 154% of the RDA (recommended daily allowance) for protein (97 grams vs. the RDA of 63 grams). The average US adult female consumes 127% of the RDA for protein. The average American derives 67% of protein from animal sources compared to worldwide average of 34%. Protein deficiency remains an important health problem in many parts of the world. WHO estimates that more than 230 million children living in the least developed countries (LDC) are stunted from protein malnutrition. This represents about 40% of all LDC children.

In the US livestock outnumber the human population 5:1. About one billion pounds (500 thousand tons) of pesticide are used annually in the US, and 35% of our food is contaminated with pesticide residues. Worldwide 2.5 million tons of pesticides are used annually, and an estimated 98% of food in India is contaminated with pesticide.

The unsanitary and crowded conditions of industrial animal production require large amounts of prophylactic antibiotics to suppress infection. Resistant strains of bacteria are emerging in response to the constant pressure of low-dose antibiotics in feed, water, and by direct ingestion. Some of these bacteria are important human pathogens, raising the possibility of resistant strains causing human disease. The high-speed meat processing common in industrial animal production provides greater opportunity for contamination of meat and the subsequent risk to humans of food-borne pathogens such as *Listeria* and Toxogenic *E. coli*.

The environmental impacts of industrial animal production are on air and water quality and nutrient runoff for river and estuary ecosystems. Excess nitrogen and phosphorous stimulates algae growth, oxygen depletion, and the creation of dead zones with fish kills and loss of other aquatic life. Air pollution with ammonia and nitrogen combined with unpleasant odors from animal waste creates intolerable living conditions for people living within several miles of large hog farms.

Individuals can act to decrease harmful pressure on the environment and reduce risk factors for disease by:

Reducing the consumption of meat and animal products in the diet
Replacing meat with high quality sources of vegetable protein (soy, beans, chickpeas)
Refining the remaining meat products by using free-range poultry, organically raised livestock and dairy products

Shifting from industrial agriculture to sustainable agriculture, which has the following characteristics, can protect the environment:

- Small farms use fewer off-farm inputs
- Integration of plant and animal production where appropriate
- Maintain higher biotic diversity
- Emphasize technologies appropriate to the scale of production
- Transition to sustainable forms of energy

In order to assure greater equity in food security, health promotion, and environmental protection we need to base our own consumption on the four principles put forward by UNDP:

- Shared - ensuring basic needs for all
- Strengthening - building human capabilities
- Socially responsible - so the consumption of some does not compromise the health, life and well being of others
- Sustainable - without mortgaging the choices of future generations

What policies should we endorse to implement these principles? UNDP's call to action includes the following:

- Ensure minimum consumption requirements for all as an explicit policy objective in all countries.
- Develop and apply technologies and methods that are environmentally sustainable for both poor and affluent consumers.
- Remove perverse subsidies and restructure taxes to shift incentives from consumption that damages the environment to consumption that promotes human development.
- Strengthen public action for consumer education and information and environmental protection.
- Strengthen international mechanisms to manage consumption's global impacts.
- Build stronger alliances among the movements for consumer rights, environmental protection, poverty eradication, gender equality and children's rights.
- Think globally, act locally. Build on the burgeoning initiatives of people in communities everywhere and foster synergies in the actions of civil society, the private sector and government.

There remain many gaps in our knowledge that need to be filled in order to create the political will needed to implement the above recommendations. Three research questions of relevance to the theme of the relationship between the built environment and health are:

- What land-use policies best support sustainable agriculture?
- Can environmental concerns be harnessed to change food consumption patterns?
- How can urban agriculture reduce fossil fuel consumption and create more green space?

The Relationship of Housing and Health On Research and Programs

David Jacobs,
US Department of Housing and Urban Development
and
Thomas D. Matte,
Center for Urban Epidemiologic Studies (CUES), New York Academy of Medicine and National Center for Environmental Health, Centers for Disease Control and Prevention

Abstract
This article provides an updated review of how the home environment can affect human health, describes how specific health hazards in housing are related to one another, and considers implications of these concerns for both research needs and programs to address the health-housing connection. The widespread availability of decent housing has contributed greatly to improvements in health status in developed countries through, for example, providing safe drinking water, proper sewage disposal, and protection from the elements. However, a lack of decent housing and homelessness among a significant number of Americans remains both a significant public health and housing concern. In addition, a number of specific health hazards can be found even in housing that is in good condition and provides all basic amenities. Specific health hazards related to housing include: unintentional injuries, exposure to lead, exposure to allergens that may cause or worsen asthma, moisture and fungi (mold), rodent and insect pests, pesticide residues, indoor air pollution and others. A number of these specific hazards share underlying causes, such as excess moisture, inadequate ventilation, poor maintenance and all may be influenced by factors in the community environment and/or by occupant behaviors. The authors make recommendations for developing programs and research efforts that address multiple housing problems in an integrated way, rather than categorically, and for closer collaboration between housing, community development and public health programs.

Keywords: housing, public health, environmental exposures, social factors

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect official policies of the US Centers for Disease Control and Prevention or the US Department of Housing and Urban Development.

Acknowledgement

This paper is updated from an earlier publication by the two authors (T.D. Matte and D.E. Jacobs, Housing and health—current issues and implications for research and programs, Journal of Urban Health: Bulletin of the New York Academy of Medicine 77(1), March 2000, 7-25). The ideas presented in this paper have been shaped in part by discussions held with individual experts in fields related to housing and health who participated in a meeting convened on December 8 and 9, 1998 by the US Department of Housing and Urban Development to solicit input in the development of its Healthy Homes initiative. Participants in the meeting included: Terry Allan, R.S., M.P.H., Bruce Lanphear, M.D. M.P.H., John Winter, Terry M. Brennan, M.S., James La Rue, Darryl Zeldin, M.D., Gary Butts, M.D., Paul Lioy, Ph.D., Liz Blackburn, Martin G. Collins, J.D., MCRP, Morton Lippmann, Ph.D., CIH, Richard Svenson, P.E., Dorr Dearborn, Ph.D., M.D., Dennis Livingston, John D. Spengler, Ph.D., Nick Farr, J.D., Steve Schwartzberg, MPH, Mary Ellen Fise, J.D., Philip Morey, Ph.D., CIH, Joseph Schirmer, CIH, Mark R. Fortney, Roger Morse, AIA, Murray Katcher, M.D., Ph.D. The authors also want to acknowledge the ideas contributed by Warren Friedman, PhD, CIH, Peter Ashley, DrPH, Molly McNairy, Patrick Bohan, David Homa, and Nancy Tips.

Introduction

Understanding the connection of housing conditions to health has involved both scientific advances and the rediscovery of historic observations and beliefs. In 1946, when Commissioner Israel Weinstein spoke on the 80th anniversary of the establishment of the Department of Health in the City of New York City, he noted: "Thus the recognition that proper housing and adequate recreational facilities are intimately related to public health is not as recent as many people think." Indeed, public health concerns related to inadequate sanitation and overcrowding in tenement housing helped to motivate the establishment of the Department of Health and to shape much of its early work.

During the latter half of this century, improvements in general housing conditions in developed countries and advances in biomedical and environmental science have resulted in the identification of new and often more subtle health concerns related to housing, such as exposure to lead-based paint hazards and indoor air pollution. Neither grossly substandard housing nor subtler environmental hazards are unique to urban homes, but the concentration of such problems in densely populated, low-income neighborhoods poses a particular challenge to public health agencies.

Despite scientific progress in understanding the connection of health to housing, two aspects of current public and private efforts to assure healthy housing may be hampering progress. First, such efforts have tended to be categorical – each program addressing a narrow range of concerns. Examples include lead poisoning prevention and injury prevention. Second, the connections between public health programs and housing/community development programs to preserve and enhance the housing stock have become more distant than they once were.

This article provides an overview of health concerns related to the home environment, considers ways in which these diverse concerns are related to one another, and discusses some implications for research and for improvement of programs related to prevention of housing-related health problems. Where relevant, the article draws on lessons learned from efforts to control exposure to leaded paint, perhaps the most studied environmental hazard in housing. The connections between health and housing are complex and multidisciplinary and we have not addressed all aspects of the problem or any one aspect in great depth. Readers seeking additional information on this topic may wish to refer to other reviews on health and housing in the biomedical and lay literature[1,2,3] and to detailed reviews of specific housing-related health concerns. A number of materials on HUD's Healthy Homes Initiative can be found at www.hud.gov/offices/lead.

Housing condition and basic amenities

Provision of safe water for drinking and personal hygiene, proper disposal of sewage, facilities for safe food preparation, and the absence of overcrowding are examples of how adequate housing can promote public health. Protection of occupants against temperature extremes and other natural hazards are also basic requirements of safe housing.[4,5] While a lack of basic facilities in housing is less frequent than it once was, the American Housing Survey documents such deficiencies in a sizable minority of the US housing stock. For example, in 1995, 1.5 percent of occupied homes lacked some or all plumbing facilities, 2.6 percent had more than one person for each room, and 5 percent had inadequate heating. Homes occupied by families below the poverty level are more than twice as likely to have a severe physical problem than other homes.[6]

A number of studies have demonstrated a relationship between general housing quality and self-reported measures of well-being,[3] but demonstrating a causal relation to physical health in developed western countries has been difficult for a number of reasons. One is the strong relationship between social disadvantage and living in poor quality housing, making it difficult to disentangle the contribution of social factors and housing conditions. In addition, poor health may impact employment opportunities and income, thereby limiting access to decent housing. So some of the health gradients

associated with housing quality may be due to selection rather than causation.[7] Still another methodologic challenge is that minimally adequate housing is available to the great majority of households in western societies, although homelessness is increasing in the U.S.[3] This limited variation in access to basic housing amenities is a limitation in individual level epidemiologic studies. Ecologic relations of secular and geographic changes in sanitation and other housing amenities to broad measures of population health make a convincing case that provision of basic housing amenities (e.g., indoor plumbing) has contributed greatly to improvements in health in developed countries.[8]

Homelessness

By one estimate, more than 7% of adult Americans have been homeless at some point and 10% of the homeless population is "chronically homeless".[9] One way of viewing homelessness would be as the low extreme of a continuum of access to decent housing. As with the impact of housing quality, it is difficult to disentangle completely the effects of low socioeconomic status, loss of housing due to disabling physical or mental illness, and the direct health impact of homelessness. However, homelessness involves a unique set of hardships beyond those presented by poor quality housing. A homeless diabetic, for example, may be faced with the impossible tasks of storing insulin and securing a diabetic diet.[10] Similarly, families of children with asthma, a common problem in some homeless populations,[11,12] are hard pressed to maintain a regular medical regimen. Lacking the physical security provided by a home, homeless women may experience more severe physical and sexual assault during their lifetime.[13]

Beyond basic amenities - Specific health hazards in housing

While many of the more recently-identified housing-related health concerns are disproportionately common in housing that is substandard in other respects (e.g., structural problems, lack of adequate heat, etc.), such housing-related environmental hazards may also exist in housing that is otherwise of good quality. Some selected examples are discussed below.

Unintentional injuries: In 1997, unintentional injuries received at home resulted in 28,400 deaths, nearly 7 million persons being disabled for at least 1 full day, and 100 billion dollars in economic costs. Common causes of fatal unintentional injuries at home include falls, fires and burns, suffocation (mechanical or by ingestion), poisoning, and firearms. Poisoning deaths among young adults, mainly due to drug ingestion, have increased from the mid-1960s to the mid-1990s, while poisoning deaths have fallen dramatically among children 0-4 during the same period.[14]

While behavioral factors play a role in household injuries, housing factors are important determinants amenable to intervention. For example, faulty heating equipment and electrical wiring contribute to the initiation of a substantial proportion of fires,[14,15] while working smoke alarms reduce the risk of death from residential fires by roughly half.[16,17] At least one smoke alarm is reported to be present in over 90% of households nationally, but they may be less common in low-income households[18] and roughly 50% may not be functioning 1 year after installation.[16] Distribution of free smoke alarms in communities where the prevalence of smoke alarms is low is an effective strategy for preventing residential fire injuries.[19]

Other examples of injuries related to modifiable features of the urban home environment include: tap water scald burns which can be prevented by setting hot water heaters to produce water below 120 degrees Fahrenheit,[18] and falls from windows which can be prevented with the use of window guards.

Interventions to prevent home injuries need not focus on a single hazard. A controlled community trial of home inspection, simple modifications, and injury prevention by outreach workers

produced significant increases in the use of smoke detectors, safe storage of medications and reduced electrical and tripping hazards.[20] In a review of controlled trials of home visits to prevent childhood injuries, Roberts et al. estimated a 26% reduction in the odds of injury based on pooled results from 8 such trials.[21]

Lead: Exposure to lead, a potent neurotoxicant, remains one of the most important and best-studied of the household environmental risks to children. Measures to eliminate or reduce the use of lead in a range of products, including gasoline, food and beverage cans, new residential paint, and potable water conduits have contributed to a dramatic decline in blood lead levels in all population groups from the mid-1970's through the mid-1990's.[22] Despite these declines, a national survey conducted from 1991-94 showed that nearly one million U.S. preschoolers still have blood lead levels in a range where subtle adverse effects on neurodevelopment have been established.[23,24] More recent data show that the mean population blood lead level in U.S. preschoolers declined by approximately 25% during the time period 1996-99, compared to 1991-94. A large reservoir of lead remains in housing built prior to the banning of leaded paint in 1978, especially in homes constructed prior to 1950 when white lead paint pigment was still widely used.[25] The most recent national survey from HUD shows that 24 million units have lead-based paint hazards, and that the number of housing units with lead paint may have declined from 64 million in 1990 to 38 million in 2000 (Jacobs et al., Prevalence of lead-based paint hazards in U.S. housing, Env Health Perspectives 110(10) A-599-A606, Oct 2002). Lead contamination of residential soil is also common, due to weathering of paint and fallout from past leaded gasoline emissions.[26] The most common pathway of residential lead exposure today is through ingestion of house dust contaminated with lead derived from deteriorated paint and tracked in soil.[27,28] The amount of lead in settled particulate on floors and window sills is the best available environmental measure for predicting the risk of elevated blood lead levels in children.[29,30] It can be performed with a widely available, inexpensive wipe test.[31]

The fraction of elevated blood lead levels in children attributable from deteriorating lead-based paint cannot be estimated precisely, but the relative prevalence of elevated blood lead levels by housing age indicates a major impact. Direct and indirect exposures of children to lead from paint are likely major factors in the prevalence of elevated blood lead levels among children living in pre-1946 dwellings (those built when the use of lead-containing paint was most common) being five times higher than among children living in homes built after 1973 (most of which do not have lead-containing paint).[32]

Strategies that include stabilization of deteriorated leaded paint, window treatments to reduce abrasion of leaded paint, and sealing and cleaning of floor surfaces result in large and sustained reductions in leaded dust in homes and little if any risk of substantial short term increases in blood lead.[33,34,35] No controlled studies are available to measure the long-term impact of these interventions on blood lead levels, but descriptive longitudinal data and a controlled study of a less extensive intervention suggest a significant benefit.[36] Extensive paint removal without adequate precautions has caused increases in blood lead levels.[37,38,39,40]

Interventions focused on reducing exposure to leaded dust and/or soil have produced modest benefits in two controlled studies.[41,42] Two other studies of abatement of soil with lower baseline contamination showed no benefit on blood lead levels.[43,44]

Allergens and asthma: The public health impact of asthma is large and increasing worldwide. In the U.S., the national prevalence of self-reported asthma among children aged 5-14 was 7.4% in 1993-94[45] and asthma is a leading cause of school absence, lost work days, emergency room visits, and hospitalizations. The especially high morbidity experienced by low-income, inner city children is

reflected in hospitalization data for New York City reported by Stevenson et al elsewhere in this issue. While no single estimate of the amount of asthma attributable to the home environment is available, exposures to certain indoor allergens, including those from dust mites, domestic pets, and cockroaches are both risk factors for development of allergies and asthma and for more severe symptoms among those already sensitized to these allergens.[46] Among inner-city children with asthma, ongoing exposure to high levels of allergen seems to be an especially common and an important cause of more severe symptoms.[47] Household allergens particles are generally sampled in settled dust because, with the exception of cat allergens, they do not stay airborne for long periods.[48,49]

Housing factors can influence allergen exposure in a number of ways. Structural defects can facilitate entry of cockroaches and rodents. High relative humidity indoors favors dust mite proliferation. Carpets and drapes can harbor allergen-containing dust.[48] Interventions that include the use of dust-mite-impervious mattress and pillow covers have been shown to reduce markers of disease severity in asthmatics.[50,46] The impact of measures to reduce other household allergens is less clear. Cockroach extermination plus family education about cleaning to remove allergen was associated with a transient decrease in cockroach allergen levels, which returned to or above baseline by 1 year after the intervention.[51] A number of ongoing studies are testing multifaceted home interventions to assess and reduce exposure to allergens and other asthma triggers.

Fungi (mold) and moisture: Allergens derived from fungi can cause allergic rhinitis, asthma, and hypersensitivity pneumonitis.[52] Certain molds found in the home environment produce mycotoxins and have been associated with a range of adverse health effects in animals including inflammation and injury in gastrointestinal and pulmonary tissues.[53,54] Increased concern about the potential risk associated with exposure to a particular fungal species, stachybotrys, followed a reported association of a cluster of pulmonary hemosiderosis (PH) cases in infants with a history of recent water damage to homes and with levels of Stachybotrys atra (SA) in air and in cultured surface samples.[55] Associations between exposure to SA and "sick building" – like symptoms in adults have also been observed.[56] Other related toxigenic fungi have been found in association with SA-associated illness and could play a role.

Mold growth in a dwelling indicates the presence of a moisture problem. In addition, there is substantial evidence that the presence of moisture problems, per se, is a risk factor for respiratory illnesses and symptoms, especially in children.[57] A number of factors might mediate such an association, including the growth of allergenic molds and higher levels of dust mite infestation.[58, 59] Excess moisture may also help to support cockroach infestation, which contributes to asthma severity in sensitized children.[60]

Although some quantitative guidelines have been established for exposure to fungi in indoor air, the health basis for these guidelines is limited by a lack of substantial, objective human dose-response data and the reliance of many studies on grab samples to characterize a chronic exposure.[61] Further research is needed to definitively establish environmental factors causing PH, other potential health risks associated with household mold exposure, techniques for characterizing exposures and hazards from residential mold contamination, and the safety and effectiveness of remediation strategies.

Rodent and insect pests: Rodents can transmit a number of communicable diseases to humans, either through bites, arthropod vectors, or exposure to aerosolized excreta.[62,63,64] In addition, humans can become sensitized to proteins in rodent urine, dander, and saliva. Structural defects in housing can make it easier for rodents to enter the home environment. According to the American Housing Survey, signs of rats in the last 3 months were reported in 2.7 million of the 97 million occupied units in the

country.[6] Surveillance of rat bite reports have been used in some jurisdictions to guide control efforts. Data from New York City in the mid-1970s showed rat bites generally occurring indoors with young children at highest risk. The decline in rat bites over time was greatest in areas with active control programs.[65]

The observed association between exposure to cockroach antigen and asthma severity has already been noted. In addition, cockroaches may act as vehicles to contaminate food and environmental surfaces with certain pathogenic organisms.[66,67]

Pesticide residues: Pesticide use, especially to control insects and rodents, is common in urban dwellings. Chlorpyriphos (CP), an organophosphate insecticide, was the most used pesticide in New York State in 1997, with the highest use occurring in two New York City boroughs.[68] While CP is a biodegradable pesticide, substantial persistence of CP on surfaces and toys has been demonstrated for at least several days following a broadcast application,[69] a use that will be phased out under a voluntary agreement between EPA and manufacturers.[70] CP residues are widely detectable in U.S. homes.[68]Animal models have demonstrated that exposure to CP in the prenatal and early postnatal period may impair neurodevelopment.[71]

Indoor air pollutants: Environmental tobacco smoke (ETS) is a carcinogen and respiratory irritant. ETS can aggravate asthma, especially in children and exposure to ETS is common among inner-city children with asthma.[72] ETS-exposed children also suffer more respiratory illnesses than other children, and have decrements in pulmonary function.

Burning of oil, natural gas, kerosene, and wood for heating or cooking purposes can release a variety of combustion products of health concern. Depending upon the fuel, these may include carbon monoxide (a chemical asphyxiant), oxides of nitrogen, sulfur dioxide (respiratory irritants), polycyclic aromatic hydrocarbons (e.g., the carcinogen benzo[a]pyrene), and airborne particulate matter. Improper venting and poor maintenance of heating systems and cooking appliances can dramatically increase exposure to combustion products.[73] A survey of unintentional nonfatal carbon monoxide poisonings in Connecticut residences found heating systems to be the most common source with gas appliances and fireplaces accounting for the remainder.[74]

A variety of chemicals released from building materials, cleaning products, and other consumer products may contaminate indoor air. Most such pollutants are classified as volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) and are thus present at highest concentrations just after installation or use. A variety of mechanisms have been proposed to link VOCs to health complaints, but establishing causal relations has been difficult due to the complex mixtures of VOCs that may be present and the diverse health complaints that have been associated with them.[75]

Use or disturbance of certain building materials can generate exposures to specific contaminants with special health concerns. Examples include asbestos fibers that can be liberated when old insulation is disturbed and formaldehyde released from particle board or medium density fiberboard.[75]

Epidemiologic studies of miners exposed to high levels of radon in inhaled air show a dose response relation for radon-induced lung cancer at high exposure levels. Though radon levels in living spaces of homes generally do not reach the levels found in these studies, extrapolation of these data has been used to estimate the excess risk of lung cancer attributable to exposure to radon gas at the lower levels found in homes. These estimates indicate that indoor exposure to radon accounts for approximately 10-14% of lung cancer deaths in the United States.[76] Excessive exposures are typically related to home ventilation, structural integrity and geographic location. Though there is regional variation in the proportion of homes with high indoor radon levels, radon concentrations can also vary

from among nearby houses and high levels may be found in all regions. Measures to reduce indoor radon levels are generally triggered by radon testing, often at the time of property sale, but only 7% of households report having had a radon test.[77]

Relationships among housing related health hazards

Many individual housing-associated health concerns are interrelated in ways that have important implications for research, policies, and programs. Excess moisture, whether caused by plumbing leaks, roof leaks, floods, groundwater intrusion into basements, or ventilation problems can contribute to a number of health hazards, including mold growth,[78] peeling leaded paint, and structural deterioration that provides access for rodent and insect pests.

Dust traps such as carpets, can harbor household allergens and can also be reservoirs for leaded dust and pesticides.[69] Treatment to control some housing-related hazards can create other health concerns. Cockroach infestation treated with organophosphate insecticides is an example. Another would be the installation of exhaust fans to control excess moisture, which, under some circumstances, can create negative pressure and cause spillage (i.e., "backdrafting") of combustion products from furnaces and hot water heaters into the living space.

Other factors contributing to health hazards in homes

Factors related to the community environment around a dwelling may impact on the home environment. Rodent infestation may be contributed to by infrequent trash removal and improper trash storage practices. The risk of injury or death from fire can be increased if fire hydrants are not working or if adjacent, attached apartment buildings or row homes lack smoke alarms and sprinklers. Overtaxed public sewers may result in sewage backups in homes that contribute to moisture and mold problems. Maintenance of homes may be influenced by owners' perceptions of economic prospects, by inspections and enforcement of housing codes, or by perceived norms of upkeep among neighborhood property owners. It is not clear whether this association is due to hazards in the individual home environments, some aspect of the neighborhood context for which housing code violations is a proxy, or some combination of the two. Understanding the impact on health of community level factors, of individual dwelling characteristics, and of interactions between the two will require multilevel studies that include measures of the neighborhood context, the home environment and health.

Occupants interact with the home environment in ways that can create new hazards or modify hazards related to the building itself. Examples include smoking, keeping pets, storage and maintenance of household chemicals, and installment and maintenance of protective devices, such as smoke alarms and carbon monoxide detectors. A distinct group of home hazards related to occupant behaviors involve so-called "fouling the nest": contamination of the home environment with substances used at work or in hobbies. When the clothing, hair, skin, or shoes of workers become contaminated with hazardous materials in the workplace, such contaminants may inadvertently be carried to the home environment. Such take-home exposures have been demonstrated, for example, in homes of lead-exposed workers.[79] In addition, certain hobbies or workplaces located in the home may provide an especially great risk of household contamination.

Implications for public health and housing programs

The relationships among individual housing-related health hazards and among the community environment, home environment, and occupant behaviors have important implications for developing future prevention programs and research. In addition, some important lessons can be drawn from the fairly long history of efforts to understand and control lead hazards associated with housing.

The need for an integrated approach. For households with the resources to obtain environmental assessment services privately, public education campaigns about healthy housing may prompt action to identify hazards in the home. In low-income urban communities, however, home visits by an environmentalist, housing inspector, outreach worker, or public health nurse may be required to identify problems. A substantial investment of time and effort is required just to schedule a visit, gain access to the home when the family is available, and complete a walkthrough inspection for a single hazard, such as lead. If the personnel carrying out home assessments are qualified and trained to identify multiple housing problems, the marginal cost of adding additional assessments, such as for fire or injury hazards, may be small relative to the overall inspection cost.

As with assessments, efficiencies may be gained in interventions by allocating certain relatively fixed costs of repairs, such as those for insurance, permits, and project management. Interventions that address several hazards at the same time can also produce notable efficiencies. Interventions that correct underlying causes may produce larger and more lasting health benefits in the long run. For example, roof repair to fix a moisture problem may not only prevent leaded paint from peeling in the future but also reduce exposure to allergenic molds. More permanent interventions may be more costly, however, and not feasible without pooling resources targeted at multiple health and housing concerns.

While it seems a reasonable hypothesis that a more integrated approach to healthy housing is more cost effective, research and demonstration projects are needed to test this strategy. Some programs using an integrated approach have already been established, and projects supported under the Healthy Homes program of the Department and Urban Development should begin to provide some answers in the coming years.[80]

Tapping larger resource pools for maintaining and improving the housing stock. Efforts to address lead paint hazards in housing have been hampered by a lack of resources to fund needed repairs in the economically distressed housing where lead poisoning often occurs. Much of the work needed to correct hazards from leaded paint, and indeed a wide range of health hazards, very often includes substantial repair, maintenance, or rehabilitation of a home. Indeed, the cost of lead hazard control can be greatly reduced if integrated into planned housing rehabilitation or routine maintenance. At the same time, financial resources for preserving and improving the housing stock are far larger than those potentially available for specific environmental and health concerns. In FY 2002, the Department of Housing and Urban Development's (HUD) Community Development Block Grant Program, for example, is funded at approximately $4.4 billion,[81] compared with roughly $110 million for HUD's healthy homes and lead paint hazard reduction program.[82] Achieving major improvements in economically distressed housing will require leveraging a variety of public and private sources of funds from housing, public health and environmental budgets to address the housing/health connection, while improving access to affordable housing and promoting homeownership.[83]

Community-level interventions. In designing and testing programs, it must be recognized that some housing problems cannot be addressed only in individual dwellings. Lead-contaminated soil and dust for example, tends to cluster in communities and both children and dust are mobile. Thus strategies for addressing lead contamination at the neighborhood level, as well as in individual dwellings, need to be developed and tested.

Need for controlled studies. Controlled studies of the effectiveness of lead hazard reduction measures have revealed some interventions to be less effective than anticipated and that others were actually

harmful. Similarly, controlled studies are needed to evaluate the effectiveness and potential risks of new interventions aimed at other hazards. Controlled studies in the home environment entail challenges beyond those of clinical investigations. For example, in rental property, both occupants and property owner consent may be required, depending on the nature of the intervention. The mobility of populations, especially low-income inner-city populations, may lead to contamination of study groups as well as loss to follow-up. While it may be possible to address these challenges in individual-level studies, they also may indicate that a community-level intervention is in order.

Primary and secondary prevention effects may differ. Housing interventions may be carried out to prevent exposure and adverse health outcomes or may be carried out in the homes of persons who have already developed a health condition to control further exposure and improve outcomes (secondary prevention). The impact of these approaches may differ substantially and studies should be designed and interpreted with attention to which approach is being evaluated. Correction of lead hazards prior to a child being exposed early in life may prevent the accumulation of a lead burden. The same intervention, carried out in the home of a lead-poisoned child may have less of an impact on blood lead due to release of lead from high bone stores.[84] Exposure to certain allergens early in life may lead to sensitization and perhaps the onset of asthma, while the same exposures later in life may trigger asthma attacks. The exposure-response relation for these two endpoints (asthma onset vs. exacerbating symptoms) may be different. A corollary would be that an intervention shown effective for primary prevention may not be effective for secondary prevention purposes and vice versa.

There may be cost implications as well. When lead paint hazards are addressed because of a child with an elevated blood lead level, arrangements for relocating the family, storing, moving, or covering furniture must be made with attendant costs and delays. Primary prevention interventions, on the other hand, may be carried out at opportune times, such as turnover of a rental unit or resale, when a vacant unit simplifies a safe intervention.

Need to understand exposure pathways. It is becoming increasingly easy to identify and measure environmental contaminants and other potential hazards in the home environment. However, environmental measurements in homes cannot guide public health action without an understanding of exposure pathways and the distribution of levels in the housing stock more generally. Here again the lead example is instructive. Past intervention approaches that focused on paint removal and did not attend sufficiently to controlling leaded dust actually caused increases in lead exposure.[37,38] Developing effective measures for preventing exposure to allergens and harmful constituents of mold will similarly require a thorough understanding of the pathways by which exposure occurs.

Need for surveillance data. Data from the National Health and Nutrition Examination Survey showing a strong relation of housing age to blood lead levels of children nationally[23] have had important policy implications. In general, though, programs to address housing related health concerns are hampered by a lack of data on the distribution of health hazards and their relation to one another in housing at the national, state and community level. While the dissemination of such data is no guarantee of policy change, it is an essential part of the decision-making process. Improvements in surveillance can be built into existing systems, by adding, for example, information about housing conditions to existing health surveys and information environmental hazards to existing housing surveys.

Collaboration between housing and public health programs. Public efforts to ensure safe housing have and will continue to have a major impact on public health. Stronger ties between housing and public health, as has existed in the past, would be helpful in a number of ways. These include: application of epidemiology and other public health sciences to the evaluation of housing programs; addressing emerging public health concerns in building and housing codes and informing this process with adequate surveillance data; and training public health and housing professionals to recognize and communicate with each other about health and housing problems encountered in the context of existing programs that include home visits, housing inspections, housing rehabilitation, and public health education.

Conclusion

Although basic living conditions have improved over the past century, the home environment can adversely impact human health in a variety of interrelated ways, some of which remain to be discovered. To address housing-related health concerns, integrated approaches that can address multiple hazards at the level of the community, the individual dwelling, and the occupants, need to be developed and tested. In order to make the best use of available resources, housing, public health and environmental concerns should be incorporated into programs that improve, preserve and provide affordable housing and into existing public health and housing surveys. Closer collaboration between the public health and housing sectors, as existed in the last century, will be required to bring about real progress.

References

[1] The Doc4Kids Project. Not Safe at Home: How America's Housing Crisis Threatens the Health of Its Children. Boston Medical Center and Children's Hospital, Boston, Massachusetts, February 1998. http://www.bmc.org/program/doc4kids/index.html, accessed 10/29/99.

[2] Lowry S. An introduction to housing and health. BMJ 1989;299:1261-2.

[3] Kasl SV. Quality of the residential environment, health, and well-being. Bull NY Acad Med 1990; 66:479-490.

[4] World Health Organization. Health Principals of Housing. Geneva, World Health Organization, 1989.

[5] APHA Program Area Committee on Housing and Health, 1968. Basic health principles of housing and its environment. Am J Public Health 1969;59:841-851.

[6] Bureau of Census. American Housing Survey for the United States in 1995. CURRENT HOUSING REPORTS H150/95RV. US Department of Commerce. Washington, 1997. http://www.census.gov/prod/2/constr/h150/h15095rv.pdf.

[7] Smith SJ. Health status and the housing system. Soc Sci Med 1990;31:753-62.

[8] CDC. Achievements in public health, 1900-1999: Control of infectious diseases. MMWR 1999;48:621-629.

[9] Link B, Susser E, Steve A, Phelan J, Moore R, Struening E. Lifetime and five-year prevalence of homelessness in the United States. Am J Public Health 1994;84:1907-1912.

[10] Lowry S. Health and homelessness. BMJ 1990;300:32-34.

[11] Efron D, Sewell JR, Horn M, Jewell F. Children in homeless families in Melbourne: health status and use of health services. Med J Aust 1996 Dec 2-16;165(11-12):630-3

[12] Weinreb L, Goldberg R, Bassuk E, Perloff J. Determinants of health and service use patterns in homeless and low-income housed children. Pediatrics 1998;102:554-62.

[13] Bassuk EL, Weinreb LF, Buckner JC, Browne A, Salomon A, Bassuk SS. The characteristics and needs of sheltered homeless and low-income housed mothers. JAMA 1996;276:640-46.

[14] National Safety Council. Accident Facts – 1998 Edition.

[15] Lowry S. Accidents at home. Br Med J 1990;300:104-106.

[16] CDC. Deaths resulting from residential fires and the prevalence of smoke alarms – United States, 1991-1995. MMWR 1998;47:803-6.

[17] Marshall SW, Runyan CW, Bangdiwala SI, Linzer MA, Sacks JJ, Butts JD. Fatal residential fires: who dies and who survives? JAMA 1998 May 27;279(20):1633-7

[18] Sharp GB, Carter MA. Prevalence of smoke detectors and safe tap water temperatures among welfare recipients in Memphis, Tennesee. J Comm Health 1992;17:351-65.

[19] Mallonee S, Istre GR, Rosenberg M, Reddish-Douglas M, Jordan F, Silverstein P, Tunell W. Surveillance and prevention of residential-fire injuries. N Engl J Med 1996 Jul 4;335(1):27-31.

[20] Schwarz DF, Grisso JA, Miles C, Homes JH, Sutton RL. An injury prevention program in an urban African-American community. Am J Public Health 1993;83:675-80.

[21] Roberts I, Kramer MS, Suissa S. Does home visiting prevent childhood injury? A systematic review of randomized controlled trials. BMJ 1996;312:29-33.

[22] Pirkle JL, Brody DJ, Gunter EW, et al. The decline in blood lead levels in the United States – The National Health and Nutrition Examination Surveys. JAMA 1994;272:284-291.

[23] Centers for Disease Control and Prevention. Blood lead levels – United States, 1991-1994. MMWR 1997;46:141-146.

[24] Centers for Disease Control and Prevention. Preventing lead poisoning in young children.

[25] U.S. Department of Housing and Urban Development. Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing, Report to Congress. Office of Policy Development and Research. Washington DC, 1990.

[26] U.S. Environmental Protection Agency. Distribution of Soil Lead in the Nations Housing Stock. Office of Pollution Prevention and Toxics. Report No. EPA 747-R-96-003. Washington DC, 1996.

[27] Bornschein RL, Succop P, Kraft KM, Clark CS, Peace B, Hammond PB. Exterior surface dust lead, interior house dust lead and childhood lead exposure in an urban environment. In Hemphill DD (ed). Trace Substances in Environmental Health, XX. Procedings of University of Missouri's 20th Annual Conference, June 1986. University of Missouri, Columbia, Missouri, 1987.

[28] Lanphear BP, Roghmann KJ. Pathways of lead exposure in urban children. Environ Res. 1997;74(1):67-73.

[29] Lanphear BP, Weitzman M, Winter NL, et al. Lead-contaminated house dust and urban children's blood lead levels. Am J Public Health 1996; 86: 1416-21.

[30] Lanphear BP, Matte TD, Rogers J, et al. The contribution of lead-contaminated house dust and residential soil to children's blood lead levels. Environ Res 1998;79:51-68.

[31] US Department of Housing and Urban Development. Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing. HUD: Washington DC, 1995.

[32] Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC. Exposure of the U.S. population to lead, 1991-1994. Environ Health Perspect 1998;106:745-50.

[33] Farfel MR, Chisholm JJ, Rohde CA. The longer-term effectiveness of residential lead paint abatement. Environ Res 1994;66:217-221.

[34] Environmental Protection Agency. Lead-Based Paint Abatement And Repair And Maintenance Study In Baltimore: Findings Based On Two Years Of Follow-Up. EPA No. 747-R-97-005. Washington: EPA, 1997.

[35] National Center for Lead-Safe Housing. Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program. Fifth Interim Report. Columbia MD, February, 1998.

[36] Staes C, Matte T, Copley CG, Flanders D, Binder S. Retrospective study of the impact of lead-based paint hazard remediation on children's blood lead levels, St. Louis. Am J Epidemiol 1994;139:1016-26.

[37] Farfel MR, Chisolm JJ. Health and environmental outcomes of traditional and modified practices for abatement of residential lead-based paint. Am J Public Health 1990;80:1240-45.

[38] Amitai Y, Graef JW, Brown MJ, et al. Hazards of 'deleading' homes of children with lead poisoning. Am J Dis Child 1987;141:758-760.

[39] Swindell SL, Charney E, Brown MJ, Delaney J. Home abatement and blood lead changes in children with class III lead poisoning. Clinical Pediatrics 1994;33:536-541.

[40] Ashengrau A, Beiser A, Bellinger D, Copenhafer D, Weitzman M. Residential lead-based-paint hazard remediation and soil lead abatement: their impact among children with mildly elevated blood lead levels. Am J Public Health 1997;87:1698-702.

[41] Rhoads GG, Ettinger AS, Weisel CP, et al. The effect of dust lead control on blood lead in toddlers: a randomized trial. Pediatrics 1999 Mar;103(3):551-5.

[42] Weitzman M, Ashengrau A, Bellinger D, Jones R, Hamlin JS, Beiser A. Lead-contaminated soil abatement and urban children's blood lead. JAMA 1993;269:1647-1654.

[43] Farrell KP, Brophy MC, Chisholm JJ Jr, Rohde CA, Strauss WJ. Soil lead abatement and children's blood lead levels in an urban setting. Am J Pub Health 1998;88:1837-9.

[44] Environmental Protection Agency. Urban Soil Lead Abatement Demonstration Project. Volume IV: Cincinnati Report. Report Number EPA 600/AP93/001d. Washington DC: EPA, 1993.

[45] Mannino DM, Homa DM, Pertowski CA, et al. Surveillance for asthma – United States, 1960-1995. In: CDC Surveillance Summaries, April 24, 1998. MMWR 1998;47(No. SS-1):1-28.
[46] Platts-Mills TAE, Vervloet D, Thomas WR, Aalberse RC, Chapman MD. Indoor allergens and asthma: report of the third international workshop. Am J All Clin Immunol 1997;100:S2-S24.
[47] Rosenstreich DL, Eggleston P, Kattan M, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. N Engl J Med 1997;336:1356-63.
[48] Bierman CW. Environmental control of asthma. Immunology and allergy clinics of North America 1996;16:753-764.
[49] Platts-Mills TA. The role of allergens in allergic airway disease. J All Clin Immunol 1998;101:S364-S366.
[50] Murray AB, Ferguson AC. Dust-free bedrooms in the treatment of asthmatic children with house dust or house dust mite allergy. A controlled trial. Pediatrics 1983;71:418-422.
[51] Gergen PJ, Mortimer KM, Eggleston PA, et al. Results of the National Cooperative Inner-city Asthma study (NCICAS) environmental intervention to reduce cockroach allergen exposure in inner-city homes. J Allergy Clin Immunol 1999;103:501-6.
[52] Verhoeff AP, Burge HA. Health risk assessment of fungi in home environments. Ann Allergy Asthma Immunol 1997;78:544-56.
[53] Nikulin M, Reijula K, Jarvis BB, Veijalainen P, Hintikka EL. Effects of intranasal exposure to spores or *Stachybotrys Atra* in mice. Fund Appl Toxicol 1997;35:182-88.
[54] American Academy of Pediatrics Committee on Environmental Health. Toxic effects of indoor molds. Pediatrics 1998;101:712-714.
[55] Montana E, Etzel RA, Horgan TE, Dearborn DG. Environmental risk factors associated with pediatric idiopathic pulmonary hemorrhage and hemosiderosis in a Cleveland community. Pediatrics 1997;99(1). URL:http://www.pediatrics.org/cgi/content/full/99/1/e5.
[56] Sudakin DL. Toxigenic fungi in a water-damaged building: an intervention study. Am J Ind Med 1998;34:183-90.
[57] Brunekreef B, Dockery DW, Speizer FE, et al. Home dampness and respiratory morbidity in children. Am Rev Respir Dis 1989;140:1363-7.
[58] Wickman J, Nordvall SL, Pershagen G, et al. House dust mite sensitization in children and residential characteristics in a temperate region. J Allergy Clin Immunol 1991;88:89-95.
[59] Verhoff AP, van Strien RT, Van Wijnen JH, Brunekreef B. Damp housing and childhood respiratory symptoms: the role of sensitization to dust mites and molds. Am J Epidemiol 1995;141:103-10.
[60] Rosenstreich DL, Eggleston P, Kattan M, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with Asthma. N Engl J Med 1997;336:1356-63.
[61] Rao CY, Burge HA, Chang JCS. Review of quantitative standards and guidelines for fungi in indoor air. J Air and Waste Manage. Assoc 1996;46:899-908.
[62] Centers for Disease Control and Prevention. Rat-bite fever – New Mexico, 1996. MMWR 1998;113:89-91.
[63] Vinetz JM, Glass GE, Flexner CE, Mueller P, Kaslow DC. Sporadic urban leptospirosis. Ann Intern Med 1996;125:794-8.
[64] Smith RP Jr, Rand PW, Lacombe EH, et al. Norway rats as reservoir hosts for Lyme disease spirochetes on Monhegan Island, Maine. J Infect Dis; 1993:168:687-91.

[65] Coombe N, Marr JS. Rat bites support need for in-home control: an epidemiologic study of rat bites in New York City, 1974-1978. J Environ Health 1980;42:321-6.
[66] Cloarec A, Rivault C, Fontaine F, Le Guyader A. Cockroaches as carriers of bacteria in multi-family dwellings. Epidemiol Infect 1992;109:483-90 .
[67] Fotedar R, Nayar E, Samantray JC, et al. Cockroaches as vectors of pathogenic bacteria. J Commun Dis 1989;21:318-22.
[68] Landrigan PJ, Claudio L, Markowitz SB, et al. Pesticides and inner-city children: exposures, risks, and prevention. Environ Health Perspect 1999;107:431-37.
69 Gurunathan S, Robson M, Freeman N, et al. Accumulation of chlorpyrifos on residential surfaces and toys accessible to children. Environ Health Persp 1998;106:9-16.
[70] Davis DL, Ahmed AK. Exposures from indoor spraying of chlorpyrifos pose greater health risks to children thancurrently estimated. Environ Health Perspect 1998 Jun;106(6):299-301
[71] Chanda SM, Pope CN. Neurochemical and neurobehavioral effects of repeated gestational exposure to chlorpyrifos in maternal and developing rats.Pharmacol Biochem Behav 1996;53:771-6
[72] Huss K, Rand C, Butz AM, et al. Home environmental risk factors in urban minority children. Ann Allergy 1994;72:173-177.
[73] Samet JM, Spengler JD. Indoor air pollution. In Rom WN (ed). Environmental and Occupational Medicine, 2nd Edition. Little Brown and Co, Boston, 1992.
[74] Centers for Disease Control and Prevention. Unintentional carbon monoxide poisonings in residential settings – Connecticut, November 1993-March 1994. MMWR 1995;44:765-767.
[75] American Thoracic Society. Achieving healthy indoor air. Report of the ATS Workshop: Sante Fe, New Mexico, November 16-19, 1995. Am J Respir Crit Care Med 1997;156:S33-S64.
[76] National Academy of Sciences. Biological effects of ionizing radiation (BEIR) VI report: the health effects of exposure to indoor radon. Executive summary. Available at http://www.epa.gov/iaq/radon/beiriv1.html.
[77] CDC. Radon testing of households with a residential smoker – United States, 1993-1994. MMWR 1999;48:683-686.
[78] Morrison Hershfeld Limited. Moldy houses: Why they are and why we care. Report to Canada Mortgage and Housing. Ottowa, Ontario. 1995.
[79] Roscoe RJ, Gittleman JL, Deddens JA, Petersen MR, Halperin WE. Blood lead levels among children of lead-exposed workers: A meta-analysis. Am J Ind Med 1999;36:475-81.
[80] U.S. Department of Housing and Urban Development Office of Lead Hazard Control. The Healthy Homes Initiative: A Preliminary Plan. APRIL 1999. http://www.hud.gov:80/lea/HHIFull.pdf, accessed October 29, 1999.
[81] US Department of Housing and Urban Development. Community Development Block Grant (CDBG) Entitlement Communities Program. http://www.hud.gov/, accessed January 14, 2003.
[82] US Department of Housing and Urban Development. HUD's Budget. http://www.hud.gov, accessed January 14, 2003.
[83] Lead-Based Paint Hazard Reduction and Financing Task Force. Putting the pieces together: Controlling lead hazards in the Nation's Housing. Washington DC: US Department of Housing and Urban Development, 1995. Publication No. HUD-1547-LBP.
[84] Gulson BL, Gray B, Mahaffey KR, et al. Comparison of the rates of exchange of lead in the blood of newly born infants and their mothers with lead from their current environment. J Lab Clin Med 1999;133:171-8.

Communities Count: Social and Health Indicators for King County, Washington

Kathryn Horsley,
Public Health – Seattle-King County

The Communities Count Project
Communities Count is committed to improving community health through information advocacy—providing accurate and timely reports on the conditions that matter to King County families and communities in order to stimulate action. The Communities Count initiative is a collaboration between the local public health department, the King County Children and Family Commission, local United Way, Sustainable Seattle, and local city and county government agencies.

Over 1500 residents helped select the core set of 29 social and health indicators. About 1320 were residents reached through a random-digit-dial telephone survey and a series of focus groups. About 30 were technical experts with knowledge about specific social and health conditions. The remaining 200 people were citizen activists, program planners, and social and health service providers and administrators. The involvement of these people was coordinated by the initiative Steering Committee and facilitated by a project management team from Sustainable Seattle and a technical support team from *Public Health—Seattle & King County*

The approach was open, iterative and incorporated carefully reported feedback from each activity sequentially. It began with the task of identifying the most important "valued conditions" for creating and sustaining the health and social well-being of individuals and communities. Next, over 125 indicator ideas that were suggested for tracking these valued conditions were evaluated and narrowed using selected criteria. In the final steps, the list was synthesized and shortened to 29 indicators. What now looks relatively simple, came through a careful and complex process.

The Process of Selecting Indicators

Telephone Survey: A random-digit-dial telephone survey was carried out in November, 1997, by *Public Health-Seattle & King County* involving 1212 adult residents of King County. The telephone survey was intended to give a representative picture of what King County adult residents value about their neighborhoods and communities, what concerns they have about the social, economic and health conditions in their region and the county, and their reaction to some suggested indicators. The results of the survey were reported to the Steering Committee and used as a touchstone of expressed values from which to further develop social and health indicators.

Focus Group Discussions with Underrepresented Groups: Lower income and education groups and non-English-speaking people were underrepresented in the telephone survey. To fill this gap, a series of focus group discussions were held with residents from the following ethnic/language backgrounds: African American, American Indian, Arab, Cuban, Cambodian, Chinese, Japanese, Korean, Laotian, Latvian, Mexican, Somali, Taiwanese, Ukrainian, Vietnamese as well as a mix of people affiliated with the local Islamic school and people who were homeless. The discussions were arranged and led by a community-based agency, the Cross Cultural Health Care Program. Results of the focus groups

and the telephone survey were used as the foundation for further public input and were revisited at every step in developing the social and health indicators.

Technical Advisory Group: A Technical Advisory Group (TAG) provided a consistent source of expert input and review throughout the process. In an iterative fashion, their response to each stage of citizen input meant that the indicator list stayed grounded in the values of the community and was augmented regularly by what the technical advisors saw as strengths and limitations of data, and the significance of certain factors to health and well being.

Civic Forums: Two civic forums provided half day, interactive working sessions with community and agency leaders and the Steering Committee. Working in small groups, participants brainstormed ideas for potential indicators. Those at Civic Forum II suggested further modifications and prioritized the most important indicators. These results were again used by the TAG and Steering Committee to refine and shorten the list. In order to provide an opportunity for involvement in different geographic locations of King County, a series of five local meetings were held in between the two county-wide civic forums. Notification was provided through mailed invitations, networking telephone calls and local media. The 45 participants reviewed the indicators clustered under 18 different topics that came out of previous work and suggested additions, deletions and modifications.

Criteria for Indicator Selection: For the set: 1) reflects whole system, 2) reflects community values, 3) balanced between basic needs and quality of life, 4) balanced between strengths and problems. For Individual Indicators: 1) valid, 2) measurable, 3) available, 4) reliable, 5) understandable, 6) provides geographic and demographic detail, and 7) suggests opportunities to take action.

Results of the telephone survey, focus groups and forums, emerged in the form of "valued conditions" that evolved into a list of potential indicators. The criteria for indicator selection were applied in a synthesis and further refinement of the indicators resulting in four broad clusters: Social Determinants of Wellbeing, Positive Development Across Life Stages, Safety and Health, and Community Strengths. The actual measures for the indicators are defined and presented in detail at http://www.communitiescount.org.

The Indicator Report

Baseline and trend data for the 29 indicators were reported in the first report card entitled *Communities Count 2000: Social and Health Indicators Across King County*. Because many of the indicators depend on measures collected by telephone surveys which tend to under-represent low income people and those who do not speak enough English to respond, a qualitative study of a few indicators was undertaken with various underrepresented groups. Focus groups were carried out in five languages with African Americans, people whose first language is Somali, Spanish, Russian, or Vietnamese, and low income people. The use of qualitative methods to elicit discussion about two indicators, social support and neighborhood social cohesion (rather than simply reproducing survey questions in various languages), led to richer and more contextual understanding of the nature of these two concepts, as well as to a more complex sense of the nature of life in King County for those who are less well-off, have less formal education, or are not English speakers. Moreover, the process of soliciting partners, and working with selected organizations through staff training, instrument refinement, recruitment, data collection, analysis, and reporting has served to inform the broader initiative. *Communities Count 2002* will report updated quantitative measures enriched by this qualitative information.

Recommendations

1) Effort should be made to refine the measures used for certain indicators, for example Stress.
2) More work should be carried out to integrate certain indicator data with GIS in order to offer the most useful spatial analysis of indicators like Ease of Access to Shops and Services, and Neighborhood Pollution.
3) Assessment experts need to be more vigilant in the development of truly community-level measures. This means going beyond aggregating individual-level survey findings.

Conclusion

The one and a half day meeting brought together a diversity of professionals interested in the impact of the built environment on human health. The ensuing discussions generated several ideas for future research and collaborations. Some of the major recommendations include:

1. Develop effective measures and indicators for sustainable communities.

2. Conduct multidisciplinary research on the positive health impacts of sustainable and planned communities.

3. Assess the environmental health benefits of efficient or alternate energy (for transportation, agriculture, architecture, community design, etc).

4. Develop models to incorporate cost effectiveness when adopting environmentally sustainable technologies.

5. Create coordinated programs among federal and non-federal agencies that address research on the built environment.

6. Encourage interdisciplinary programs for training and research within governmental and non-governmental agencies.

7. Improve communication strategies among various partners; especially encourage community participation in research endeavors.

8. Develop multilevel techniques of measurement and longitudinal models of analysis for assessing the impact of the built environment on sustainable communities. These measures and models should account for individual, community and systemic variables including biological factors, socioeconomic factors, neighborhood and physical environment variables, etc.

9. Identify factors and variables that mediate and moderate built environment health effects.

10. Study methods and channels to translate research findings into policy and to the community-at-large that improve public health.

As a result of the conference, NIEHS has identified the built environment as an area of special emphasis, and thus has been encouraging increased focus on research that examines the interactions between the built environment and human health.

For more information on NIEHS activities pertaining to the built environment and other translational research activities, please visit the NIEHS Translational Research web pages at:

http://www.niehs.nih.gov/translat

Appendix 1: Meeting Agenda

BUILT ENVIRONMENT – HEALTHY COMMUNITIES, HEALTHY HOMES, HEALTHY PEOPLE: MULTILEVEL, INTERDISCIPLINARY RESEARCH APPROACHES

IN CONJUNCTION WITH THE

HEALTH DISPARITIES GRANTEE MEETING

Monday, July 15, 2002

Morning

8:00	Registration	
9:00	Introduction	Dr. Frederick Tyson DERT, NIEHS
9:10	NIEHS Welcome	Dr. Anne Sassaman Director, DERT, NIEHS
9:20	OBSSR Welcome	Dr. Lawrence Fine Medical Advisor, OBSSR
9:30	Opening Remarks	Dr. Samuel Wilson Deputy Director, NIEHS
	"Environmental Health and the Built Environment"	
10:00	Break	
10:20	**Environmental Health and Sustainable Communities**	

Description: The presentations will highlight the importance of including environmental health in policy deliberations that in the long term create communities that are sustainable. The presentations will focus on providing some broad based framework for the discussion on built environment and the creation of sustainable communities which incorporate improved environmental and public health. Sustainable communities are those that seek to balance the social, economic, cultural, and the ecological infrastructure with human health and development.

1. Howard Frumkin, Emory University — 20 min.
   "Environmental Health and Sustainable Communities"
2. Virginia Rauh, Columbia University — 20 min.
   "Deteriorated Housing: A Toxic Environmental Exposure"
3. Alexis Karolides, Rocky Mountain Institute — 20 min.
   "Design As If People Mattered: Fostering Health and Productivity in the Built Environment"

Health Disparities grantees will discuss their research in context of session theme.

1. Arnold Spokane — 10 min.
   Built Environment and Hispanic Elders Behavioral Health
2. Alice Tarbell & Lawrence Schell — 10 min.
   Mohawk Culture, Behavior, Toxicant Exposure and Health

Discussant	10 minutes	Dr. Samuel Wilson
Panel Discussion with Audience Participation	20 minutes	

Afternoon

12:30 Lunch

Introduction — Mr. Liam O'Fallon, CEMBB, NIEHS

1:45 Keynote — Dr. Richard Jackson, Director, NCEH, CDC

"Unhealthy Growth and Systematic Environmental Disease: The Need for research and Policy on Built Environment and Health"

2:15 **Health Impacts**

Description: Creation of communities that are environmentally healthful requires an understanding of the impact of the structure of the built environment and urban ecosystems on air and water quality in homes, offices, and industry, the system of transportation and the emissions of automobiles, etc. This session will highlight the importance of planning that is cognizant of environmental health in the creation of healthy communities, healthy homes and healthy people.

1. George Thurston, New York University School of Medicine — 20 min.
   "Air Pollution and Its Health Effects"

2. Lawrence Frank, Georgia Institute of Technology 20 min.
"Measuring Relationships Between Urban Form, Physical Activity Levels, and Public Health"
3. Bryan Williams, University of Arizona 20 min.
"Inter- and Intra-Ethnic Variation in Water-Related Exposures and Environmental Risk Perception Among Tucson Residents: The Role Of Culture & Environmental Equity"

3:15 Break

3:30 **Health Impacts (continued)**

Health Disparities grantees will discuss their research in context of session theme

1. Paul Blanc 10 min.
Adult Asthma: Biology, Society and Environment
2. Carolyn Berry 10 min.
Social Factors and the Environment in Pediatric Asthma

Discussant 10 minutes Dr. Richard Jackson
Panel Discussion with
Audience Participation 20 minutes

4:30 Adjourn

5:30 Posters displaying the Health Disparities Grantees Projects & Reception

7:00 Conclude for the day

Tuesday, July 16, 2002

Morning

8:00 Introduction Dr. Shobha Srinivasan
CEMBB, NIEHS

8:30 Opening Remarks Dr. Kenneth Olden
Director, NIEHS

9:00 Keynote Dr. Trevor Hancock
Chair, Board of the Canadian Association of Physicians for the Environment
"Healthy Buildings in Healthy Communities in Healthy Ecosystems: Sustaining People and the Planet"

9:30 **Partnerships for Environmentally Healthful Communities**

Description: The creation of communities that are cognizant of the environment and the health of its citizens require partnerships among policy makers, governments, researchers, communities, and health specialists who have an interdisciplinary perpective. This session will highlight several programs that have developed partnerships to create sustainable communities and that have a positive impact on public health.

1. Robert Lawrence, John Hopkins University 20 min.
   The Built Environment: Health Damaging or Health Promoting
2. David Jacobs, US Department of Housing and Urban Development, 20 min.
   "HUD's Healthy Homes Initiative: Building the Partnership Between Housing and Health"
3. Kathryn Horsley, Public Health – Seattle-King County 20 min.
   "Communities Count: Social and Health Indicators for King County, Washington."

10:30 Break

10:45 **Partnerships for Environmentally Healthful Communities (continued)**

Health Disparities grantees will discuss their research in context of session theme

1. Amy Schulz, Srimathi Kannan, Alison Benjamin, Zachary Rowe 10 min.
   Social and Physical Environments and Health Disparities Project
2. Hester Lipscomb 10 min.
   Work and Health Disparities Among Rural Women

Discussant –	10 minutes	Dr. Trevor Hancock
Panel Discussion with Audience Participation	20 minutes	

11:45 Synthesis and Wrap Up — Dr. Allen Dearry, Chief, CEMBB, NIEHS

12:15 Adjourn

12:30 HD Grantee Meeting (closed session)

Appendix 2: Participant List

Built Environment – Healthy Communities, Healthy Homes, Healthy People: Multilevel, Interdisciplinary Research Approaches

July 15–16, 2002
Sheraton Imperial
Research Triangle Park, NC

List of Participants

Robin Argue, M.P.H.
Research Assistant
Duke University Medical Center
P.O. Box 3834
Durham, NC 27710
Phone: (919) 286-1722
Fax: (919) 286-1021
E-Mail: robin.argue@duke.edu

Jennifer Balfour, Ph.D.
Assistant Research Scientist
University of Michigan
1214 South University, Room 243
Ann Arbor, MI 48104-2548
Phone: (734) 647-9741
Fax: (734) 998-0006
E-Mail: jbalfour@umich.edu

Edna Ballard
Clinical Associate
Duke University Medical Center
P.O. Box 3600
Durham, NC 27710
Phone: (919) 660-7510
Fax: (919) 684-8569
E-Mail: elb@geri.duke.edu

John Barefoot, Ph.D.
Research Professor
Duke University Medical Center
P.O. Box 2969
Durham, NC 27710
Phone: (919) 684-2403
Fax: (919) 681-8960
E-Mail: foot@acpub.duke.edu

Thomas Bedick
Chief
Facilities Engineering Branch
National Institute of Environmental Health Sciences
P.O. Box 12233, MD 102-01
Research Triangle PK, NC 27709
Phone: (919) 541-3327
Fax: (919) 541-1583
E-Mail: bedrick@niehs.nih.gov

Alison Benjamin, B.A.
Program Manager
Contaminated Sites Program
Southwest Detroit Environmental Vision
P.O. Box 09400
Detroit, MI 48209
Phone: (313) 843-6376
Fax: (313) 842-1961
E-Mail: swdev@flash.net

Carolyn Berry, Ph.D.
Associate Research Professor
New York University
726 Broadway, Fifth Floor
New York, NY 10003
Phone: (212) 998-7465
Fax: (212) 995-4166
E-Mail: carolyn.berry@nyu.edu

Paul Blanc, M.D., M.S.P.H.
Professor of Medicine
University of California, San Francisco
350 Parnassus Avenue, Suite 609
San Francisco, CA 94117
Phone: (415) 476-7377
Fax: (415) 476-6426
E-Mail: blancp@itsa.ucsf.edu

Alan Borner, B.A.
President
Healthy Indoor Environments, Inc./EHMI
P.O. Box 932
Durham, NH 03824
Phone: (603) 868-1496
Fax: (603) 868-1547
E-Mail: aborner@aol.com

Philip Bors
Project Officer
Active Living by Design
UNC School of Public Health
CB 8165
400 Market Street, Suite 205
Chapel Hill, NC 27516
Phone: (919) 843-3081
Fax: (919) 843-3083
E-Mail: phil_bors@unc.edu

Mohamed Boubekri, Ph.D.
Associate Professor
School of Architecture
University of Illinois
117 Temple Buell Hall
611 Taft Drive
Champaign, IL 61820
Phone: (217) 333-2848
Fax: (217) 244-2900
E-Mail: m-boule@uiuc.edu

Jeffrey Braff, Dr.P.H.
Mount Zion Hospital
University of California, San Francisco
Mailstop 1640
1600 Divisadero Street, Room C446
San Francisco, CA 94115
Phone: (415) 353-7525
Fax: (415) 885-7724
E-Mail: jpbraff@medicine.ucsf.edu

Elizabeth Carlton, B.S.
Program Coordinator
Columbia Center for Children's
Environmental Health
60 Haven Avenue B-1
New York, NY 10032
Phone: (212) 305-3241
Fax: (212) 305-4012
E-Mail: ec2060@columbia.edu

Ginger Chew, Sc.D.
Assistant Professor of Clinical Public Health
Mailman School of Public Health
Columbia University
60 Haven Avenue, Room B-1
New York, NY 10032
Phone: (212) 305-1692
Fax: (212) 305-4012
E-Mail: cg288@columbia.edu

Leslie L. Clarke, Ph.D.
Associate Professor
Health Policy and Epidemiology
University of Florida
P.O. Box 100177
Gainesville, FL 32610-0177
Phone: (352) 265-8041
Fax: (352) 265-8047
E-Mail: lc1960@comcast.net

Eugene Cole, Dr.P.H.
Professor
Health Science Department
Brigham Young University
229-C Richards Building
Provo, UT 84602
Phone: (801) 422-7491
Fax: (801) 422-0273
E-Mail: gene_cole@byu.edu

Gwen Collman, Ph.D.
Scientific Program Administrator
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-4980
Fax: (919) 316-4606
E-Mail: collman@niehs.nih.gov

Cecil D. Corbin-Mark
Program Director
West Harlem Environmental ACTion, Inc.
271 West 125th Street
New York, NY 10027
Phone: (212) 961-1000
Fax: (212) 961-1015
E-Mail: cecil@weact.org

Catherine Cubbin, Ph.D.
Research Associate
Stanford Center for Research
in Disease Prevention
1000 Welch Road
Palo Alto, CA 94304
Phone: (650) 498-4626
Fax: (650) 725-6906
E-Mail: ccubbin@stanford.edu

Lesley Curtis, Ph.D.
Director
CERTS Data Center
Duke Clinical Research Institute
2400 Pratt Street
Durham, NC 27705
Phone: (919) 668-8753
Fax: (919) 668-7124
E-Mail: pratt001@mc.duke.edu

Allen Dearry, Ph.D.
Chief
Chemical Exposures and Molecular Biology
Division of Extramural Research and Training
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-4943
Fax: (919) 541-4606
E-Mail: dearry@niehs.nih.gov

Dana Dolinoy, B.A.
Project Manager
Duke University Medical Center
P.O. Box 90328
Durham, NC 27710
Phone: (919) 613-8088
Fax: (919) 684-8741
E-Mail: dcd@duke.edu

Carlton Eley
Environmental Protection Specialist
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Phone: (202) 260-7154
Fax: (202) 260-0174
E-Mail: eley.carlton@epa.gov

Ramon Estrada, E.M.B.A.
Director
Child and Family Resources
2800 East Broadway
Tucson, AZ 85716
Phone: (520) 321-3753
Fax: (520) 325-8780
E-Mail: restrada@cfraz.org

Stephanie Farquhar, Ph.D.
Assistant Professor
School of Community Health
Portland State University
P.O. Box 751
Portland, OR 97207
Phone: (503) 725-5167
Fax: (503) 725-5100
E-Mail: farquhar@pdx.edu

Lawrence Fine, Ph.D.
Research
Office of Behavioral and Social Sciences
National Institutes of Health
1 Center Drive, Room 256
Bethesda, MD 20892
Phone: (301) 402-1146
E-Mail: finel@od.nih.gov

Lawrence Frank, Ph.D.
College of Architecture
Georgia Institute of Technology
Atlanta, GA 30332-0155
Phone: (404) 894-6488
Fax: (404) 894-1628
E-Mail: larry.frank@arch.gatech.edu

Howard Frumkin, M.D., Dr.P.H.
Professor and Chair
Emory University
1518 Clifton Road
Atlanta, GA 30322
Phone: (404) 727-3697
Fax: (404) 727-8744
E-Mail: medhf@sph.emory.edu

Thomas Glass, Ph.D.
Assistant Professor
Bloomberg School of Public Health
Johns Hopkins University
615 North Wolfe Street
Baltimore, MD 21205
Phone: (410) 614-7028
Fax: (410) 614-2632
E-Mail: tglass@jhsph.edu

Kimberly Gray, Ph.D.
Health Science Administrator
National Institute of Environmental
Health Sciences
12233 T.W. Alexander Drive
MD EC-21
Research Triangle Park, NC 27502
Phone: (919) 541-0293
Fax: (919) 316-4606
E-Mail: gray6@niehs.nih.gov

Susan L. Haithcock
Extramural Program Assistant
Office of Program Development
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-27
Research Triangle Park, NC 27709
Phone: (919) 541-1403
Fax: (919) 541-4937
E-Mail: haithco2@niehs.nih.gov

Trevor Hancock, M.D.
Chairman of the Board
Canadian Association of Physicians
for the Environment
28 Napier Street
Klienburg, Ontario, LOJ ICO
Phone: (905) 893-2808
E-Mail: thancock@on.aibn.com

Jeanne Hewitt, Ph.D.
Associate Professor and Associate Director
Milwaukee Institute of Environmental Health
University of Wisconsin
P.O. Box 413
Milwaukee, WI 53201
Phone: (414) 229-5463
Fax: (414) 229-6238
E-Mail: jbhewitt@uwm.edu

Kathryn Horsley, Ph.D.
Dept of Public Health
999 3rd Avenue
Wells Fargo Center No.1200
Seattle, WA 98104-4039
Phone: (206) 296-2789
Fax: (206) 205-5314
E-Mail: kathryn.horsley@metrokc.gov

Andrea Hricko, M.P.H.
Director of Community Outreach and Education
Keck School of Medicine
University of Southern California
1540 Alcazar Street
CHP 236
Los Angeles, CA 90405
Phone: (323) 442-3077
Fax: (323) 442-3272
E-Mail: ahricko@usc.edu

Richard Jackson, M.D.
Director
National Center for Environmental Health
Centers for Disease Control and Prevention
4770 Buford Highway, Mailstop F-29
Atlanta, GA 30341-3724
Phone: (770) 488-7000
E-Mail: rxj4@cdc.gov

David Jacobs, Ph.D.
Office of Healthy Homes
and Lead Hazard Control
U.S. Department of Housing
and Urban Development
451 Seventh Street, SW, P-3202
Washington, DC 20410
Phone: (202) 755-4973
E-Mail: david_e_jacobs@hud.gov

Srimathi Kannan, Ph.D.
Assistant Professor
University of Michigan
1420 Washington Heights
Ann Arbor, MI 48109
Phone: (734) 936-1629
Fax: (734) 764-5233
E-Mail: kannans@umich.edu

Alexis Karolides
Rocky Mountain Institute
1739 Snowmass Creek Road
Snowmass, CO 81654-9199
Phone: (970) 927-3851
Fax: (970) 927-4510
E-Mail: alexis@rmi.org

Carolyn Kawecki, M.A., R.N.
Program Manager
National Center for Healthy Housing
10227 Wincopin Circle
Columbia, MD 21044
Phone: (410) 772-2779
Fax: (410) 715-2310
E-Mail: ckawecki@enterprisefoundation.org

Jody Lally, M.A., M.S.W.
Project Manager
University of Massachusetts, Lowell
218 Weed Hall
3 Solomont Way
Lowell, MA 01854
Phone: (978) 934-4270
Fax: (978) 934-4028
E-Mail: jody_lally@uml.edu

Bruce Lantrip, Sc.D.
Program Manager
Applied Environmental Health
Research Services
102F Woodwinds Industrial Court
Cary, NC 27511
Phone: (919) 463-0522
Fax: (919) 463-0527
E-Mail: aerobio@bellsouth.net

Barbara Latham, M.P.H.
Research Assistant
National Center for Environmental Health
Centers for Disease Control and Prevention
4770 Buford Highway, NE
Atlanta, GA 30341-3724
Phone: (770) 488-7245
Fax: (770) 488-4178
E-Mail: blatham@cdc.gov

Robert Lawrence, Ph.D.
School of Hygiene and Public Health
Johns Hopkins University
615 N. Wolfe Street, Suite W-1033
Baltimore, MD 21205
Phone: (410) 614-4590
Fax: (410) 614-8126
E-Mail: rlawrenc@jhsp.edu

Julie Linton, B.S.
Intern in Aging Center
Duke University Medical Center
P.O. Box 3600
Durham, NC 27710
Phone: (919) 660-7510
Fax: (919) 684-8569
E-Mail: julie.linton@duke.edu

Hester Lipscomb, Ph.D.
Associate Professor
Duke University Medical Center
P.O. Box 3839
Durham, NC 27710
Phone: (919) 286-1722 x 256
Fax: (919) 286-1021
E-Mail: hester.lipscomb@duke.edu

Nicole Lurie, M.D., M.S.P.H.
Senior Natural Scientist
RAND Corporation
1200 South Hayes Street
Arlington, VA 22202-5050
Phone: (703) 413-1100
E-Mail: lurie@rand.org

Frank Martinez
Associate Professor
School of Architecture
University of Miami
2211 Northwest 4 Terrace
Miami, FL 33125
Phone: (305) 643-3711
Fax: (305) 643-9916
E-Mail: fmartinez@miami.edu

Patrick Mastin, Ph.D.
Scientific Program Administrator
OSTB
Division of Extramural Research and Training
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-23
Research Triangle Park, NC 27709
Phone: (919) 541-3289
Fax: (919) 541-5064
E-Mail: mastin@niehs.nih.gov

Tanya McDuffie
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-7725
Fax: (919) 316-4606
E-Mail: mcduffi1@niehs.nih.gov

Carlos Mendes de Leon, Ph.D.
Associate Professor
Rush Institute for Healthy Aging
Rush-Presbyterian-St. Luke's Medical Center
1645 West Jackson Boulevard
Chicago, IL 60612
Phone: (312) 942-3350
Fax: (312) 942-2861
E-Mail: cmendes@ruch.edu

Marie Miranda, Ph.D.
Associate Professor of the Practice
Duke University Medical Center
P.O. Box 90328
Durham, NC 27710
Phone: (919) 613-8023
Fax: (919) 684-8741
E-Mail: mmiranda@duke.edu

Robert Musil
Executive Director and CEO
Physicians for Social Responsibility
1875 Connecticut Avenue, NW, Suite 1012
Washington, DC 20053
Phone: (202) 667-4260
Fax: (202) 667-4201
E-Mail: bmusil@psr.org

Liam O'Fallon, M.A.
Program Analyst
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-2506
Fax: (919) 316-4606

Kenneth Olden, Ph.D.
Director
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD B2-01
Research Triangle Park, NC 27709
Phone: (919) 541-3201
Fax: (919) 541-2260
E-Mail: olden@niehs.nih.gov

Ted Outwater
Public Health Educator
Worker Education and Training Program
National Institute of Environmental
Health Sciences
P.O. Box 12233
RTP, NC 27709
Phone: (919) 541-2972
Fax: (919) 541-0462
E-Mail: outwater@niehs.nih.gov

Warren Pope
Administrative Officer
Division of Extramural Research and Training
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-20
Research Triangle Park, NC 27709
Phone: (919) 541-7691
Fax: (919) 541-2843
E-Mail: pope@niehs.nih.gov

Laura Punnett, Sc.D.
Professor
University of Massachusetts, Lowell
One University Avenue
Lowell, MA 01854
Phone: (978) 934-3269
Fax: (978) 452-5711
E-Mail: laura_punnett@uml.edu

Kelly Quinn, M.P.H.
Project Director
Evanston Northwestern Healthcare
Research Institute
2650 Ridge Avenue
Evanston, IL 60201
Phone: (847) 570-1740
Fax: (847) 570-2933
E-Mail: kquinn@enh.org

Virginia Rauh, Sc.D.
Deputy Director
Children's Environmental Health Center
Helibrunn Center for Population
and Family Health
Columbia University
2960 Broadway
New York, NY 10027-6902
Phone: (212) 305-4177
Fax: (212) 305-2015
E-Mail: var1@columbia.edu

Renee Robin, J.D.
Director
Children's Environmental Health Network
1604 Solano Avenue
Berkeley, CA 94707
Phone: (510) 526-0081
Fax: (510) 526-3672
E-Mail: rlrobin@earthlink.net

William Rohe, Ph.D.
Professor
University of North Carolina, Chapel Hill
No. 3410
Chapel Hill, NC 27599
Phone: (919) 962-3077
Fax: (919) 962-2518
E-Mail: brohe@unc.edu

Nancy Rothman, Ed.D., R.N.
Independence Foundation Professor
of Urban Community Nursing
Temple University
3307 North Broad Street, 602-00
Philadelphia, PA 19140
Phone: (215) 707-5436
Fax: (215) 707-5181
E-Mail: nrothman@vm.temple.edu

Zachary Rowe
Program Director
Friends of Parkside
P.O. Box 14168
Detroit, MI 48213
Phone: (313) 822-0311
Fax: (313) 822-9343
E-Mail: foparkside@aol.com

Kate Ryan
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-3254
Fax: (919) 316-4606
E-Mail: ryan3@niehs.nih.gov

Susan Saegert, Ph.D.
Professor
Environmental Psychology
City University of New York Graduate Center
365 Fifth Avenue
New York, NY 10016
Phone: (212) 817-1886
Fax: (212) 817-1564
E-Mail: ssaegert@gc.cuny.edu

Megan Sandel, M.D., M.P.H.
Assistant Professor of Pediatrics
Boston Medical Center
91 East Concord Street
Boston, MA 02118
Phone: (617) 414-3680
Fax: (617) 414-3679
E-Mail: megan.sandel@bmc.org

Anne Sassaman, Ph.D.
Director
Division of Extramural Research and Training
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-20
Research Triangle Park, NC 27709
Phone: (919) 541-7723
Fax: (919) 541-2843
E-Mail: sassaman@niehs.nih.gov

Peter Scheidt, M.D., M.P.H.
Program Office Director
National Children's Study
National Institute of Child Health
and Human Development
6100 Executive Boulevard, Room 7B03
Bethesda, MD 20892-7510
Phone: (301) 496-6287
Fax: (301) 402-2084
E-Mail: scheidtp@nih.gov

Lawrence Schell, Ph.D.
Professor
State University of New York, Albany
Arts & Science Building 237
1400 Washington Avenue
Albany, NY 12222
Phone: (518) 442-4714
Fax: (518) 442-4563
E-Mail: l.schell@albany.edu

Lisa Schuetz, M.A.
Community Outreach and Education
Program Coordinator
New York University School of Medicine
57 Old Forge Road
Tuxedo, NY 10956
Phone: (845) 731-3532
Fax: (845) 351-2728
E-Mail: lisa@env.med.nyu.edu

Amy Schulz, Ph.D.
Assistant Research Scientist
University of Michigan
1420 Washington Heights
Ann Arbor, MI 48109
Phone: (734) 647-0221
Fax: (734) 763-7379
E-Mail: ajschulz@umich.edu

Brian Schwartz, M.D., M.S.
Professor
Bloomberg School of Public Health
Johns Hopkins University
615 North Wolfe Street, Room 7041
Baltimore, MD 21205
Phone: (410) 955-4158
Fax: (410) 955-1811
E-Mail: bschwart@jhsph.edu

Madeleine Shalowitz, M.D., M.B.A.
Director of Health Services Research
Department of Pediatrics
Evanston Northwestern Healthcare
Research Institute
2650 Ridge Avenue
Evanston, IL 60201
Phone: (847) 570-1129
Fax: (847) 570-2933
E-Mail: m-shalowitz@northwestern.edu

Ilene Siegler, Ph.D., M.P.H.
Professor of Medical Psychology
Duke University Medical Center
Box 2969
Durham, NC 27710
Phone: (919) 684-6352
Fax: (919) 681-6960
E-Mail: ilene.siegler@duke.edu

Carlos Siqueira, Sc.D., M.P.H.
Research Assistant Professor
University of Massachusetts, Lowell
One University Avenue
Lowell, MA 02130
Phone: (978) 934-3147
Fax: (978) 452-5711
E-Mail: carlos_siqueira@uml.edu

Craig Slatin, Ph.D.
Assistant Professor
University of Massachusetts, Lowell
One University Avenue
Lowell, MA 01854
Phone: (978) 934-3291
Fax: (978) 934-3025
E-Mail: craig_slatin@uml.edu

Arnold Spokane, Ph.D.
Professor
Lehigh University
111 Research Drive
Bethlehem, PA 18015
Phone: (610) 758-3257
Fax: (610) 758-6223
E-Mail: ars1@lehigh.edu

Shobha Srinivasan, Ph.D.
Scientific Program Administrator
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-0176
Fax: (919) 316-4606
E-Mail: sriniva2@niehs.nih.gov

Donnette Sturdivant
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-4667
Fax: (919) 316-4606
E-Mail: sturdiv1@niehs.nih.gov

William A. Suk, Ph.D.
Deputy Director
Division of Extramural Research and Training
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-27
Research Triangle Park, NC 27709
Phone: (919) 541-0797
Fax: (919) 541-4937
E-Mail: suk@niehs.nih.gov

Maureen Sullivan, M.Ed.
Executive Director
Urban Appalachian Council
2115 West Eighth Street
Cincinnati, OH 45204
Phone: (513) 251-0202
Fax: (513) 557-2542
E-Mail: maureen@one.net

Jolie Susan, B.S.
Project Coordinator
Bloomberg School of Public Health
Johns Hopkins University
615 North Wolfe Street, Room W7604
Baltimore, MD 21205-2179
Phone: (410) 502-7968
Fax: (410) 955-1811
E-Mail: jsusan@jhsph.edu

Alice Tarbell, B.S.
Program Director of the COEP
First Environment Research Projects
State University of New York, Albany
32 Garrow Road
Akwesasne, NY 13655
Phone: (518) 358-9930
E-Mail: ferp@northnet.org

George Thurston
Nelson Institute of Environmental Medicine
New York University School of Medicine
57 Old Forge Road
Tuxedo, NY 10987
Phone: (845) 731-3564
Fax: (845) 351-5472
E-Mail: thurston@env.med.nyu.edu

John Tibbetts
942 Carmel Drive
Charleston, SC 29412
Phone: (843) 727-2078
Fax: (843) 727-2080
E-Mail: tibbetts@comcast

Frederick Tyson, Ph.D.
Scientific Program Administrator
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD EC-21
Research Triangle Park, NC 27709
Phone: (919) 541-0176
Fax: (919) 316-4606
E-Mail: tyson2@niehs.nih.gov

Sheryl Weir, M.S.W.
Program Manager
University of Michigan
1420 Washington Heights
Ann Arbor, MI 48109
Phone: (734) 615-2695
Fax: (734) 763-7379
E-Mail: ssweir@umich.edu

Charles A. Wells, Ph.D.
Director
Environmental Justice/Health Disparities
National Institute of Environmental
Health Sciences
31 Center Drive, MSC 2256
Building 31, Room B1C02
Bethesda, MD 20892-2256
Phone: (301) 496-2920
Fax: (301) 496-0563
E-Mail: wells1@niehs.nih.gov

Bryan Williams, Ph.D.
Director
Environment Behavior and Risk Research Lab
University of Arizona
4875 North Hummingbird Lane
Tucson, AZ 85750
Phone: (520) 626-3406
Fax: (520) 626-8362
E-Mail: bryanw@u.arizona.edu

Redford Williams, M.D.
Professor of Psychiatry and Behavioral Sciences
Duke University Medical Center
P.O. Box 3926
Durham, NC 27710
Phone: (919) 684-6352
Fax: (919) 681-8960
E-Mail: redfordw@acpub.duke.edu

Samuel Wilson, Ph.D.
Deputy Director
National Institute of Environmental
Health Sciences
P.O. Box 12233, MD B2-06
Research Triangle Park, NC 27709
Phone: (919) 541-3267
Fax: (919) 541-3592
E-Mail: wilson5@niehs.nih.gov

Gary Winkel, Ph.D.
Professor
Environmental Psychology
City University of New York Graduate Center
365 Fifth Avenue
New York, NY 10016
Phone: (212) 817-8724
Fax: (212) 817-1564
E-Mail: gwinkel@gc.cuny.edu

Marilyn Winkleby, Ph.D.
Associate Professor of Medicine
Stanford University
1000 Welch Road, Room 302
Palo Alto, CA 94304-1825
Phone: (650) 723-7055
Fax: (650) 725-6906
E-Mail: winkleby@stanford.edu

Rosalind Wright, M.D., M.P.H.
Instructor in Medicine
Channing Laboratory
Harvard Medical School
181 Longwood Avenue
Boston, MA 02115
Phone: (617) 525-0867
Fax: (617) 525-0958
E-Mail: rosalind.wright@channing.harvard.edu

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

P.O. Box 12233 Research Triangle Park, North Carolina 27709-2233 www.niehs.nih.gov